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U. S. Congress. Senate. Select committee on irrigation and reclamation of arid lands

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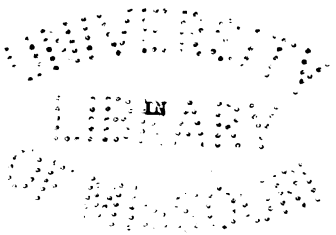
IRRIGATION



THE UNITED STATES.

BY

RICHARD J. HINTON.

[*Special Agent in charge of Artesian Wells Investigation*, 1890, *Department of Agriculture.*]

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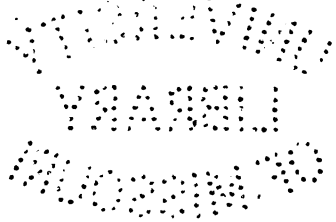

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IRRIGATION IN THE UNITED STATES.

EXTENT AND METHODS. AREA OF RECLAMATION. THE STATISTICS THEREOF. ARTESIAN WELLS. LAWS OF STATES AND TERRITORIES. WATER SUPPLY. RATES AND DISTRIBUTION; WITH BRIEF SKETCH OF FOREIGN SYSTEMS, ETC., ETC.

PREPARED BY

RICHARD J. HINTON.

BEING A

SECOND EDITION OF SENATE MISCELLANEOUS DOCUMENT No. 15, 49th CONGRESS.

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IRRIGATION IN THE UNITED STATES.

[Prepared by order of the United States Senate Special Committee on Irrigation and Reclamation of Arid Lands.]

PART I.

THE ARID REGION.

An inquiry into the progress and present condition of irrigation in this country necessarily involves a consideration of the extent and character of the area within which the annual rain-fall is not sufficient for the industrial uses of the people. Such an inquiry, broadly defined, involves the extent of the fall of rains or snow within the area indicated; also the evidence obtained as to increase or decrease of precipitation resulting from agricultural settlement or of pastoral occupation, the increase of humidity of earth or air, the destruction of the timber mainly by its use for settlement purposes, the effect of the destruction of the native grasses and the substitution of cultivated varieties; also the sources of water supply, their character, uses, conservation, the means, natural and artificial, employed for their distribution, and what has been and is being accomplished in the way of artificial methods of water distribution and economy, and the laws and customs pertaining thereto. More than any of these, however, it relates itself fundamentally to the largest questions of physical geography. The topographical configuration involves, indeed it controls, the whole matter of aridity, because it determines all climatic considerations. The probability of reclamation by means of irrigation is primarily by the configuration of a given hydrographic area.

Incidentally, the questions arising from deforesting, on the one hand, and of arboriculture, on the other, are related to the inquiry, and have been brought out to some extent. The aim has been to give the actual facts upon these subjects, so far as they could be supplied from observation, experience, experiments, and realized results. This effort has been measurably successful. It has brought together a mass of facts and observations that shed much light on the questions involved, giving a broader idea of the importance of irrigation, and adding greater value to a very large area of the United States, of whose agricultural capabilities but small account has heretofore been taken. It will be developed by the facts herein presented that the area of the irreclaimable arid lands within the boundaries of the Union is, comparatively speaking, quite moderate in its extent. There is, however, a very large area, embracing at least one-third of our total land service, wherein the water supply, whether subterranean and surface-flow or in the form of precipitation, is both inadequate and irregular in character.

The eastern boundary of this great area may at present be assumed to be the one hundredth meridian of west longitude. The western boundary may be in part placed at the Pacific Ocean, though more ac-

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curately the Coast Range of California would be the line. The northern boundary is the British territorial line west from the one hundredth degree to the summit of the Sierras, or the one hundred and twentieth meridian. Following the summits of the main range, the northwest line would deflect to the central portion of Oregon, following the southwesterly bend of the mountains down to the northern boundary of California. The southern limit of this dry area would be the northern line of Mexico, and thence south by east, along the Valley of the Rio Grande, down to the Gulf of Mexico. The area then, east and west, through its central and larger portion, runs from the one hundredth meridian to the one hundred and twenty-fourth degree of west longitude, and in its greatest prolongation north and south from the forty-third to the twenty-seventh degree of latitude. In its more northern portion it runs east and west from the ninety-eighth to the one hundred and twentieth degree of west longitude. The larger portion from north to south is embraced between the thirty-second and forty-third degrees of latitude, with the sub-arid or semi-humid area, the eastern line of which, though irregular, may safely be stated as the ninety-seventh meridian, the total area extends east and west for nearly twenty-eight degrees of longitude.

These lines cover nearly one-half of the States of Kansas and Nebraska, both States of Dakota, the whole of the States of Colorado, Montana, and Nevada, with nine-tenths of California, one-third of Texas, and about one-third of Oregon; also the Territories of Wyoming, New Mexico, Utah, Idaho, and Arizona, with at least one-third (east of the mountains) of Washington. This embraces about one-third of our whole territorial surface, inclusive of Alaska. How much of the latter-named Territory may be wholly or partially arid or desert in character can not yet be estimated. The east and west lines of this dry region, then, are, in the widest section, over 1,300 miles apart, and in its greatest length, the northern and southern limits are about 1,000 miles apart. If the whole region were compactly arranged it would make a block about 1,000 miles square. The area thus indicated may be subdivided again into three broad divisions, as follows:

(1) The plains region, running north and south from the British American line to the lower portion of the Rio Grande Valley in Texas, and east and west from the one hundredth to the one hundred and fifth degrees of west longitude. This division may be broadly declared to have a general rise and altitude of from 1,500 to 5,000 feet, though it will fall below that at either end of the area. It is but sparcely supplied with streams, which are mainly fed from mountain sources; the annual precipitation is nearly everywhere below a reliable amount for economic uses. In the central portion this precipitation will not, under favorable conditions, exceed 18 inches per annum in the eastern part, and as we go westward it diminishes to 12 and 15 inches per annum.

In the southern (Texas) portion of this area the rain-fall will somewhat exceed 20 inches on the east, decreasing until, on the northwest, it will reach only 8 to 10 inches in the most favorable seasons. In the northern or Dakota portion the average is more evenly maintained. This division will include the western half of Kansas and Nebraska, one-third (or the eastern foot-hills and plains region) of Colorado, the major portion of Dakota, the eastern half of Wyoming Territory, and one third or more of the Indian Territory and Texas, with about one-fourth (or the eastern part) of New Mexico. It is drained by a number of streams, some of them of importance, and is bounded on the east and north by the Missouri River and its affluents, and by the Pecos and

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Cimarron Rivers on the west and southwest. Its soil is almost uniformly fertile. Natural grasses of most nutritious quality are found throughout its area. It is the most important grazing section of the West.

Large farming settlements are moving steadily and compactly westward from the eastern line. At various points in its western portion there are important farming communities, created mainly by the use of water as applied through irrigation ditches and by other means of storage and distribution. The valley of the Upper Rio Grande, from the San Juan Range in southern Colorado, to where the river debouches from New Mexico into Texas and becomes the boundary-line between the United States and Mexico, has for many generations been the seat of local and unsystematized irrigation works. The Pueblo or town-dwelling Indians have for centuries practiced it. Since the Spanish conquest, in the sixteenth century, the mixed Mexican people who have inhabited this district have always been obliged to irrigate in order to cultivate. In these latter days our own more enterprising people are inaugurating and carrying on larger enterprises and projects, whose advantages are already perceivable.

(2) The second great division can be more distinctly characterized as the arid section of the United States. It lies between the one hundred and fifth and the one hundred and twentieth meridians, taking in the whole of our intra-mountain region, from the foot-hills of the Rockies to the lower slopes and foot-hills of the Sierras Nevada in California, and extending north and south from British America to Mexico. Within this area, except on the higher and arid heights of the ranges, principal or secondary, there is generally good pasturage for cattle. The natural grasses are sun-cured, and afford ample food and range for many million head of cattle.

The problem of water supply is, however, one for serious consideration. There are desert tracts and areas within this great region which are undoubtedly arid and desolate to the extent of irreclaimability. Their extent is a matter yet unsettled, especially in view of the great enterprises projected and in progress in both Colorado and California. Even the mountain plateaus, which, from altitude as well as aridity would seem to be undoubtedly sterile, may yet be found useful, not only in providing for cattle, but, possibly under systematic plans of forest-culture, they may be made the means of protecting the water sources and otherwise favorably modifying climatic and terrene conditions.

The defined outlines of this second division embrace the great basin section, of which Utah and its water reservoir—the great Salt Lake—are the dominating physical and geological features; the Colorado plateau region, which occupies the larger portion of Southern Nevada and Northern Arizona; the beautiful parks of the Rocky Mountains or the eastern flank and ranges of the North American Cordillera system; the table-lands of southern Arizona, and the great valleys and basin formed on the north by the Columbia River and its important affluents in eastern Oregon, Idaho, and Montana.

Arid and desert as this stupendous mountain system may seem to be, it will be found on examination to have large sections capable of agricultural uses, and also to hold within its borders such sources and supplies of water as, properly conserved, protected, and distributed, under the wise and conservative direction of the national and State Governments, will be found of ample utility for the purposes (1) of larger pastoral uses; (2) of more limited and localized, but still extensive, agricultural purposes; and (3) as storage and reservoir sources, from

which at no distant day the life-giving waters may be conveyed to and distributed over vast areas, which even our present limited experiences prove to be convertible into fertile farms.

A glance at a good topographical map will indicate to the observant eye the areas under reference. For example, the central section of the Rockies (in Colorado, Wyoming, and a portion of New Mexico) contain the sources of important rivers. This hydrological area is extensive, as there are numerous lakes, some of considerable size, while the snow precipitation is also quite heavy.

Inquiry and examination will satisfy the inquirer that in the extreme west the higher Sierras yield from the snow precipitation alone an amount of water which, under proper engineering conservation and wise plans of distribution, carried out for the common weal rather than for corporate profit, would supply the whole great valley and foot-hills region of central and southern California, now being so largely developed as a wheat and fruit growing region. The eastern slopes of the Sierras belong as drainage area to the huge hydrographic basin of which Nevada is the chief portion. The snows and storage of that region should readily reclaim 3,000,000 acres in western Nevada.

In the northern portion of our intra-mountain area the hydrological system, comprising the Columbia and Snake Rivers and their affluents, will certainly give a sufficient water supply both for pasturage and agriculture.

East of the Cascade Mountains the climate and natural features of the country are very different from those of the great basin lying west of them, so that the popular divisions, eastern and western Oregon and Washington, are fully warranted. In the eastern section the thermometer is much higher in summer and lower in winter than in the western section. The rain-fall is not half as heavy. From June to September there is no rain. The winters are short, but occasionally severe. Snow seldom falls before Christmas, and, though it sometimes lies from four to six weeks, it usually disappears in a few days. The so-called "Chinook," a warm wind, blows periodically, and melts deep snows in the course of a few hours.

In Eastern Oregon and Washington spring begins in February, and lasts until the middle of May. At this season rain falls in sufficient quantity to give life to vegetation and insure good crops. The average temperature is 52°. The rain-fall of the year does not average more than 20 inches. South of the Snake River it is not more than 15 inches, increasing gradually to the northward.

In the southern portion of this area, where the Colorado plateau descends to the valleys of the Gila, Colorado, and Rio Grande, forming the table-lands of Southern Arizona and New Mexico, there has already been utilized a water supply sufficient for cattle, and in several extended portions, as in the valleys of the Gila, Rio Verde, Salt, Colorado, Chiquita, San Pedro, and Santa Cruz Rivers, almost enough to meet the present agricultural and horticultural demands has been turned to account.

It may be estimated, then, that, of our whole intra-mountain region below the timber line as herein outlined, at least 60 per cent. affords fair pasturage, with sufficient watering-places, though often at long intervals apart, and subject to various limitations, which are rapidly being in a degree overcome, and will hereafter largely disappear as more attention and skill are directed to the subject. The facts gathered from Utah and Nevada will show how large are the possibilities of improvement in this direction. No really accurate estimate can be made as to

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the proportion of this intra-mountain area that may be reclaimed for arable and horticultural purposes; but it is not extravagant to claim that when the accessible water sources shall be brought into use, one-fifth of its acreage (as already defined) may be so utilized. In a very large portion the per cent. will be quite small; in other portions it will greatly exceed the general estimate here made. It must be borne in mind that in both estimates the higher mountain sections, embracing at least one-fifth of the whole region, are excluded. Yet, on the summit of the highest plateau region in northern Arizona, for instance, cattle are successfully wintered at an altitude of from 7,000 to 10,000 feet above the sea.

(3) The third division, which might fairly be ranked first in point of interest, embraces the Pacific coast region from the western slopes of the Sierra Nevada (in California) to the ocean, and takes in the great transverse valley troughs or plains cradled between the Sierra foothills and the Coast Range, the great wheat granary of the Golden State, and also the fruit-growing section, yearly rising in importance.

In treating of these three divisions of the arid region more in detail they will be taken up in inverse order, beginning with the one named last in the above statement.

THE PACIFIC COAST DIVISION.

This division embraces the State of California, lying between the one hundred and twentieth degree of west longitude and the Pacific Ocean, east and west, and between the fortieth and thirty-first degrees of north latitude.

In the San Joaquin Valley, at Fresno, and at different points in southern California, as Los Angeles, San Gabriel, Riverside, Anaheim, San Diego, water is found to be attainable at moderate depths, and apparently in all directions. This subterranean supply, wherever it has been reached and utilized, is greatly reducing the need of surface irrigation.

Fruit growers and wheat farmers in southern California unite in the testimony that after irrigation has been practiced for some years a given supply of water suffices for a largely-increased area, the explanation being that when water is first applied to arid land a large part of it sinks deep into the dry earth, or is carried away latterally by seepage; whereas, when the lower strata and, to some extent, the lands adjoining those under irrigation, are moistened, the amount of water absorbed in excess of the actual needs of vegetation becomes comparatively small. How much effect this increased humidity of the soil may have on the atmospheric humidity is not yet known, but the increase of evaporation due to this circumstance and to the cultivation of trees and plants must ultimately produce a beneficial change in this regard.

The full industrial use of water in California must necessarily be governed by the larger topographical and other physical conditions. The precipitation seldom exceeds 22 inches annually, and over a greater portion of the State falls below that figure. The wide range of variation in rain-fall is illustrated by the following facts: At Fort Redding the range of three years was from 15.9 inches to 37.4 inches; at Sacramento the range of seventeen years was from 11.2 inches to 27.5 inches; at Millerton, six years, from 9.7 inches to 49.3 inches; at Stockton, three years, from 11.6 inches to 20.3 inches; at Fort Tejon, five years, 9.8 inches to 34.2 inches; at Monterey, five years, from 8.2 inches to 21.6

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inches; at San Diego, twelve years, 6.9 inches to 13.4 inches; at Benicia, twelve years, 11.8 inches to 20 inches. The above figures show the rainfall for calendar years; the following show the amount of precipitation during the rainy season: Clear Lake, 1,300 feet elevation, six years, 16.2 inches to 66.7 inches; Visalia, three years, 6.7 inches to 10.3 inches; San Francisco, twenty-two years, 7 inches to 49.3 inches; Pillarcitos, nine years, 39 inches to 82 inches; Sacramento, twenty-four years, 4.7 inches to 36.4 inches; San Diego, twenty-two years, 4.5 inches to 14.8 inches.

The importance of California warrants a fuller description of the State, its topography, and other conditions bearing on the question of irrigation within its limits. There are two great mountain ranges running northwest and southeast, namely, the Sierra Nevada and the Coast Range. The former is from 4,000 to 8,000 feet high and the latter from 1,000 to 6,000 feet. The two ranges are connected in the southern part of the State at Tehachipi, and in the northern at Mount Shasta. The Sierra Nevada Range extends along the eastern border of the State and is about 450 miles long. The Coast Range extends along the coast to the northern and southern boundaries of the State. The base of the Sierra Nevada Range north of Fresno has an average width of about 80 miles. The Coast Range averages about 65 miles in width. Between the two ranges are the great Sacramento and San Joaquin Valleys, which together are about 450 miles long by 55 miles wide, and may be termed the heart of the State.

In the northern part of the State, and north of the junction of the two great mountain ranges, is the Klamath Basin, through which the Klamath River runs for a distance of 225 miles, between steep hills and mountains and rocky cañons, in a southwesterly course to the ocean. The whole basin of the Klamath is very rugged for a distance of 40 miles from the coast, and along the main river there is very little valley or bottom-land. However, there are several small rich valleys and near the lakes there are large fertile tracts. Pine, cedar, and fir forests cover the mountains, and there are other valuable trees, both on the mountains and in the valleys. In the extreme southeastern portion of the State is the Colorado Desert, about 140 miles long by 70 miles wide, which is the dry bed of a former inland sea. Another great basin, called the Mojave Basin, lying north of the Colorado Desert, extends into the southern part of the State, the surface of which is cut up by many irregular ridges of mountains.

The Coast Range is composed of a multitude of ridges and is intersected by numerous long and narrow valleys of fertile soil, comprising those of the Los Angeles, Salinas, Santa Clara, Sonoma, Napa, and Russian Rivers. The State has numerous small rivers. In the central portion are the Sacramento and San Joaquin, each in its meanderings about 350 miles long. These are the only navigable streams in the State. From the Sierra Range westward into the Sacramento flow the Pitt, Feather, Yuba, American, Consumnes, and Mokelumne Rivers. Into the San Joaquin flow the Calaveras, Stanislaus, Tuolumne, Merced, Chonechilla, and Fresno. Into Tulare Lake flow the Kings, Kameah, Tule, and White Rivers, and into Kern Lake the Kern River. All of these are considerable streams, with an average length of about 120 miles. The upper half of each is in the steep and rugged mountains, where they are torrential in character. After reaching the plain their currents are gentle, and the banks low, fringed with oak, sycamore, cottonwood, and willow.

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The rivers of the Coast Range flowing westward into the ocean south of San Francisco are the San Lorenzo, Pajaro, Salinas, Carmel, El Sur, and Cuyama, Santa Inez, Santa Maria, San Buenaventura, Santa Clara, Los Angeles, San Gabriel, Santa Ana, Santa Margarita, San Luis Rey, and San Diego. Many of these are constant streams to within 10 or 15 miles of their mouths, and all of them pass through rich valleys. North of San Francisco the streams of the Coast Range which empty into the ocean are the Russian, Eel, Elk, Mad, Klamath, and Smith Rivers, besides many others of less importance, all of which are permanent streams, bordered with narrow valleys at the foot of the mountains. To all of the rivers of the State flow many small tributaries. There are several important lakes, the Tulare, Owens, Kern, Clear, Klamath, Goose, Fall, Eagle, Honey, Elizabeth, Tahoe, Mono, and Dry Lakes. There are also a number of smaller ones.

The southern portion of the great interior basin of California is commonly known as the San Joaquin Valley, although it comprises the San Joaquin, Tulare, and Kern Valleys. The Tulare Valley is separated from the first named by a low ridge of land, scarcely noticeable, and in times of high water the southern lakes and rivers find an outlet through Fish and Fresno Sloughs into the San Joaquin River, thence to San Francisco Bay. Properly, there is no division lying between the San Joaquin and Sacramento Valleys. The greatest length of San Joaquin Valley is 260 miles, the width varying from 30 to 70 miles. The area is 11,290 square miles, or 7,225,600 acres. The eastern and western sides of the valley slope from the base of either range of mountains towards the lakes or streams in the lowest part, at the rate of 5 to 8 feet per mile; also northward to tide-water in San Francisco Bay, with a general fall of 1 foot to the mile.

The Mount Diable or main Coast Range on the west side of the valley has an average height of about 1,700 feet. The Sierra Nevada Mountains on the eastern side of the valley rise to a much greater height. Mount Whitney, in Tulare County, has an altitude of 15,056 feet, and is the highest peak within the United States. From this mountain the summit-line of the range gradually lessens in height towards the north and more rapidly to the south. These mountains are rugged and broken, sharp, rocky ridges and granite spires rising abruptly to great altitudes. In the small valleys between these ridges is perpetual snow, and about the base of Mount Whitney are a number of small glaciers. This region has some of the wildest, grandest, and most beautiful scenery in the world. The San Emidio, or Tejon Mountains, a spur running at right angles to the Sierra and Coast Ranges, and joining the two, form the southern boundary of the San Joaquin Valley. The foot-hills commence in the northern part of Fresno County at an altitdue of 309 feet above sea level, and in the extreme southern end of the valley at a height of 400 feet. In the hills are many valleys, some of them large and level, others more uneven.

In the Coast Range there are few valleys. About the base of the range are gently-sloping table-lands at an altitude of 100 to 250 feet above the valley, from which the mountains ascend to sharp and narrow ridges cut transversely at intervals of a few miles by natural passes extending through the range. The flanks of the Sierra broaden towards the south. The Sierra foot-hills in the portion of Tulare County, midway between the northern and southern boundaries, rise suddenly from the plain, but to the northward and southward, in Fresno and Kern Counties, the slope is more gradual, the hills lower, and the belt wider.

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THE RAISIN VINEYARD REGION.

To the eye of the traveler the plain generally presents a very level surface. In Fresno County, on the eastern slope of the valley, are scattered hillocks 20 to 30 feet in height, with a wide base, rendering them inconspicuous even at a short distance. These are not observable elsewhere in the Southern San Joaquin Valley. Extending along the entire length of the eastern side of the valley, near the foot-hills, is a belt of uneven country known as "hog-wallow" land. These "hog wallows" are little mounds ranging from a few inches to 3 or 4 feet in height, averaging 1 to 2 feet, with a diameter of 16 to 50 feet. There are no deep river-beds traversing the upper part of the valley, although further north these are common. The beds of the southern streams, in fact, are in almost every case higher than the general level of the plain, having been built up into low, wide ridges, by the alluvium deposited during the rainy season through a long series of years.

Fresno, Tulare, and Kern Counties form the southern part of the San Joaquin Valley. The three counties have an aggregate area of 21,770 square miles, or about 13,932,800 acres. Of this large extent of country 13,885 square miles, or 8,886,400 acres, are mountain and hill land; and 7,885 square miles, or 5,046,400 acres, are in the valley, making a body of arable land in these three counties (deducting the surface covered with water) equal to some of the larger Eastern States. The land is divided among the counties as follows: Fresno, 4,480 square miles, or 2,867,200 acres, of mountain and hill land, and 3,520 square miles, or 2,252,800 acres, of valley land; Tulare, 3,835 square miles, or 2,454,400 acres, of mountain and hill land, and 1,775 square miles, or 1,136,000 acres, of valley land; Kern, 5,570 square miles, or 3,564,800 acres, of mountain and hill land, and 2,590 square miles, or 1,657,600 acres, of valley land, including the gently sloping plain skirting the base of the hills. There is a more gradual ascent from the valley proper in Kern than in either of the other two counties. The numerous valleys, large and small, in the mountains and foot-hills are not estimated as valley land.

THE SAN JOAQUIN ARTESIAN WELLS.

There is a large portion of the southern San Joaquin Valley that is not wholly dependent upon the streams for irrigation, considerable water being obtainable from artesian wells. The artesian belt extends from one end of the valley to the other. A good flow is usually obtained in boring to a depth of 300 to 600 feet. The first successful boring for artesian well water in Tulare County was made by the Southern Pacific Railroad in 1879 near Tipton, and a flow rising half an inch above the rim of the casing was secured at a depth of 310 feet. The well is on the eastern margin of the belt. This water was used for irrigating a 40-acre tract of forest trees, which it did successfully.

No rock is encountered in boring, strata of sand, clay, and gravel succeeding one another. It is therefore necessary to use iron casing the whole distance, which is forced down after the auger. The depth at which the first water-bearing stratum of sand or gravel is penetrated is from 310 to 640 feet, although some of the wells have been put down to a depth of 800 feet, passing through several of these strata. The deepest in Tulare County are in the northwestern part, near Lemoore. The section in which the greatest number of good, flowing wells have been obtained is west of the Tulare and near Tipton, the water from some

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of them rising to a height of 5 or 6 inches above the casing. Wells are also shallower here than about Lemoore. The average depth in Tulare County is about 450 feet. There are in Tulare County about three hundred wells. It is impossible to give the exact number, as so many new ones are being bored. In Kern and San Bernardino Counties the number is not less than five hundred.

In Fresno County fewer wells have been bored. In the southern part of the county water is obtained in one well at a depth of 152 feet. Others have been bored in the region bordering on the San Joaquin River, the depth of these averaging from 150 to 200 feet. In Kern County, at the southern extremity of this great basin, artesian wells were bored several years ago and water was obtained at a depth of 200 to 250 feet, the average depth being less than in Tulare County. Some fifteen or twenty wells have been bored in the county. One, 470 feet deep, furnished about 30 gallons per minute. Others have been bored north of Poso Creek, in the region about Delano and Alila, and elsewhere in the county. The average flow from the wells of Tulare County may be placed at 2½ inches above the casing.

The quantity of water furnished by a well of this capacity is about 247 gallons per minute, or a little more than half of a second-foot. In parts of the San Joaquin Valley shallow wells have been known to fail after two or three successive years of light rain-fall and to flow again after a wet season. This has not happened in the southern portion of the valley. The deeper wells continue to flow regularly. It is claimed that some of the wells in Tulare County will each irrigate 160 acres of land thoroughly, and after the ground has been irrigated and cultivated a number of years and the methods of applying the water perfected a greater acreage can be successfully watered. More recent observations show that these wells are periodical as to flow, being larger and with more power when the mountain snows are melting than at any other time.

The Mussel Slough region in Tulare County was the first to be irrigated on a large scale, and soon became famous for the productiveness of its land. In the foot-hills there is generally sufficient rain, except in very dry years, to mature crops. Where the soil is loose and sandy and where irrigation has been in use for a term of years little water is required other than that supplied by the rain-fall, the ground being sufficiently moist from seepage. In places moisture will permeate the ground for miles from the ditches. In some portions of Kern County the farms comprise from 640 to 1,800 acres, and the checks made for irrigating are surrounded by strong, low embankments, made with a view to permanency. The ditches are made on the highest land, and the levees inclosing these irregularly-shaped checks are built so as to take advantage of the natural inequalities in the surface.

VALUE OF THE FOOT-HILLS.

The foot-hill region contiguous to the great valley which has been frequently referred to deserves more extended notice. This belt is of varying width, extending along the Sierra Nevada Mountains. In the mild climate of the Southern Joaquin plain it is most valuable for the growth of citrus and other semi-tropical fruits. It is particularly adapted to early fruits of all kinds. It has already been stated that fruit ripens much sooner in the orchards of the Fresno and Tulare County foot-hills than on the plains. The same is true of Kern County. Experience demonstrates that in the valley at the mouth of Kern River Cañon,

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twelve miles from the Southern Pacific Railroad at Sumner, frosts begin one month earlier than in the valley, and cease a month earlier in the spring, and during the coldest period are less severe than on the plain.

Peaches in the foot-hills have ripened a month earlier than on Kern Island; all kinds of stone fruits mature early, while other kinds that do not bear well or regularly in the valley grow to perfection here. An isothermal line drawn through the axis of this belt would traverse the lower and more easily cultivated portion of the foot-hills, and at the southern end of the valley would extend upward and inland to the abrupt mountain wall where Kern River Cañon bisects the range, where it would approach nearer to the valley than farther north, owing to the topography of the mountains and not to other conditions influencing climate. Above the thermal belt, extending through the region of black oak to and into the pine and redwood forests, is an extensive area adapted to the production of a great variety of crops, and particularly to those fruits that require a cooler climate than that of the lower foot hills and plain. The soil is rich, but the greater part of the hill land is covered with a dense growth of chamiso, manzanita, chaparral, and other brush, which must be cleared before the land can be cultivated.

Small clearings have already been made, and the result has been to encourage others to enter or purchase and do likewise. At no distant day this will be an important section of the agricultural and fruit-growing portion of the three counties named. It is a healthy region. The rain-fall is greater than in the valley, and by conducting water from the mountain streams by the system of piping employed in other parts of the State a sufficient supply can be obtained to irrigate all the best cultivable land, and by the conservation of water in reservoirs during the wet season the small streams could be depended upon to furnish a sufficient supply for a large aggregate area not readily reached by the main streams. Above an altitude of 1,200 feet in Fresno, 1,500 feet in Tulare, and 2,000 in Kern County there is sufficient rain-fall to make irrigation useful but not an absolute necessity.

In the region midway between the plain and the mountains proper the hills are generally precipitous, and although small valleys are numerous, there are few of any considerable area. Land in the southern San Joaquin Valley remote from water supplies has in only a very few instances advanced materially above Government price; whereas that lying contiguous to or supplied with water has advanced several hundred per cent. in value, having been converted from grazing to productive agricultural and fruit land. In Fresno County only has the colony plan of settlement been carried to any great extent. At present there are two colonies in Tulare County, and one or two large tracts of land for sale in lots of 10 to 40 acres. Twenty acres are sufficient for fruit growing, and 40 acres is the largest tract that one man or family should attempt to cultivate, for it pays better to give careful attention to 20 or 40 acres than to imperfectly work more. The first colony started in Fresno County was the Central, near the town of Fresno, on the west side of the railroad. The land on which it was located was a treeless, uninviting plain, and, except in the wet season, verdureless. Now the elm, fig, cherry, and other trees give names to the avenues along which they are planted, and the tract presents a succession of flourishing orchards and vineyards, with scores of beautiful and comfortable homes, surrounded by shrubbery, green lawns, and flowers. Other colonies have since been started, and are in a more or less ad-

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vanced state. The principal ones are the Washington, Nevada, Fresno, Scandinavian, Easterby, and American, which follow in the order named.

THE DRAINAGE BASINS.

The area of California in its relations to irrigation falls into the following divisions:

(*a*) The natural area of sources, supply, and reservoirs; that is, the higher portions of the Sierra Nevada, upon the western flanks and summits of which the snow precipitation is heavy, whose physical formation creates the great catchment basins, and whose altitude is sufficient to break, deflect, and desiccate the great moisture-bearing currents from the Pacific Ocean.

(*b*) The foot-hills region, extending from Mount Shasta to the San Bernardino Range. This is the seat also of the important mining operations of the State. It is, consequently, the area in which the water-supply section has been largely drawn upon and made extensively available by means of catchment areas, dams, ditches, and flumes. It is also especially in what is designated as the lower foot-hills where the altitude is below 2,500 feet, an area in which these supplies and distributing agencies, natural and artificial, have been extensively utilized for agricultural and horticultural purposes.

Experience has proved that in this subdivision of the State, which for all practical purposes embraces nearly all of Northern California, irrigation must, for such industrial purposes, be heavier and more continuous than elsewhere. Irrigation enterprises therein have up to date been largely of a personal and individual character, except where the hydraulic mining companies have utilized their larger water-works and channels, with the surplus waters they controlled, by selling the latter to the farmers and horticulturists of the region.

(*c*) This subdivision embraces the great valley region of the State, its most important wheat and grain growing section, and includes the extensive drainage basins of the Sacramento, San Joaquin, Feather, Bear, Yuba, American, Cosumnes, Mokelumne, Tuolumne, Merced, Kings, Fresno, Kern, and other streams, large and small. It covers an area of over 34,000 square miles, divided into sixteen counties, within which every problem connected with the industrial use of water and its conservation, legal and practical, is in process of both application and discussion. The most extensive canal system, and the combination of farming interests in the control of supply, or the application of capitalistic enterprise to induce land settlement primarily and water purchase subsequently, are to be found therein.

There are also, as already noted, well-developed artesian belts in the upper portions of this region. The lower portions are subject to tidal overflow and river inundations, while the existence of water at a moderate depth is being demonstrated in almost every portion of the great valley areas. This region embraces not only the major portion of the wheat-producing area, but is also the seat of large viticultural and horticultural activity.

PLANTING AND SUB-SURFACE WATER SUPPLY.

Perhaps the most gratifying as well as significant fact developed by the irrigation experience of California, especially in the valley region, is that connected with quality of the soils, which are generally of great thickness and tenacity. Underlying the surface soils there are found

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almost everywhere at moderate depths, impervious strata, by which the water drawn too rapidly from the overdrained surface has been happily preserved. Owing to this almost generally established condition of things, water throughout the northern as well as the central portions of the State is being obtained from ordinary wells. It is pumped to the surface and distributed by the agency of the peculiar wind-mills in use, which are now known in all parts of the world.

The altitude of the California valleys is nowhere very great, and the lower portions are at but moderate heights above sea-level. That of the foot-hills region is from 2,500 to 4,000 feet. California experience brings into prominence the question whether the cultivation of the soil in surface-dry and wind-desiccated areas, such as the valleys and lower table-lands of that State were assumed to be but a few years since, does not of itself tend directly to an increase of surface humidity by capillary attraction, or the drawing upon the water supplies that are unquestionably found in the underlying strata. Another question suggested is, whether such supplies are not to be found flowing below or underlying considerable areas of the valley plains and table-land regions of Central and Southern California and elsewhere within our dry areas. The precipitation of rain and snow, with the annual melting of the latter, would be in itself sufficient to feed such subterranean bodies.

It is evident that these aqueous supplies do not directly flow to the ocean within the hydrological channels and basins that have been worn through the surface and other strata. The streams and rivers of California do not carry volume enough to account for the amount of deposition that must occur within the sub-division designated as the source and supply area of the Sierras. If subterranean bodies of water exist they will be utilized by borings. The high altitude at which waters disappear into the earth must give them, when arrested under the table-lands and plains below by impervious strata, a force ample to propel the same up and above the surface, and to give them the value of living perennial streams or springs. In fine, there are two sources of subterranean waters to be utilized in California for fuller industrial purposes. The first is the water arrested in its flow from the surface at moderate depths, and which can be reached and drawn upward by the loosening of the soil consequent upon cultivation, and by the hardy and penetrative qualities of the plant roots. The other source is to be found in the deeper bodies that are presumably the lost and sunken floods of the Sierras. That such bodies exist there is more than mere conjectural data to indicate.

RECLAIMABILITY OF MESA AND DESERT LANDS.

Passing from these points, the other division of southern California embraces some of the features of both the valley and foot-hills regions. It is also affected in its western portion by the trade winds and other coast influences, and its extreme southern and eastern section is modified and molded by the great Colorado plateau formation of which the boundary mountains and mesas, or table-lands, are in fact a part. There are great stretches of arid mesa, or secondary table-land, which must be counted as desert, though the major portion has native grasses sufficient to feed a large number of animals. There is also sufficient development, especially in Los Angeles and San Bernardino Counties, to indicate the possibility of profitable reclamation in the case of considerable portions of these so-called deserts, provided the waters now available, explored, and in part utilized, can be distributed over their surface.

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The southern California division approaches, in many of its products, a semi-tropical fertility and luxuriance. It is the chief seat of the orange culture. The lemon, olive, date, fig, almond, pomegranate, nectarine, and other fruit trees requiring warm and fecund soils, grow in abundance there. The upper or northerly part of this subdivision forms a part of the great wheat-producing area of the State.

The table-land or mesa portions are also extensively utilized for the pasturage of cattle and sheep. In the southern section of California the absence of any considerable hydrological basins with flowing waters in them makes the method of conservation of great significance. The economic use of water therein has almost approached perfection. The conservation of the Los Angeles River and of other similar but smaller streams, within the three great counties into which Southern California is legally divided, is in proof of this.

WATER LAWS AND REGULATIONS.

The practical legal issues involved in the conservation and distribution of water for economic uses within the State of California are of a most serious character.

There are district community methods of control, as seen in the laws and policy found operative within the State. The first comes from the admixture of the Indian community, or pueblo life, with that of the Spanish conqueror, both being affected and shaped by the needs and customs of people to whom irrigation has always been a prime necessity. The Indian, with his tribal, clan, or village organization, has regarded land and water as common or communal property, in the use of which all had a right. The Spaniard regarded the land as his by conquest, but held that the water, being necessary for its full utilization and profit, must be controlled by the king, *i. e.*, the state, and therefore should be for the public use. The English common-law doctrine of riparian rights has no place in the economy of either people. The public charge of the water supply at Los Angeles and elsewhere in southern California illustrates the perfection to which the community may bring control and distribution. The discovery of gold brought with it in California the rapid adoption of a miners' code, both as to the occupation of mineral "claims" and the control of water rights.

This code has become the foundation of nearly all our legislation, State and national, as to the disposition and use of the mineral lands, and, in a minor degree, it has also dominated and shaped the water usages so far as mining is concerned. The public use of water is fairly established in that connection; but as to the other and larger utilization of water in agriculture, the drift of events within the dry area seems to have been for a long time in the opposite direction. This tendency began early in the construction of large works in the upper foot-hills and Sierra regions, for the purpose of obtaining a water supply large enough to carry on the great hydraulic enterprises which, for a quarter of century past, have been so marked a feature of California gold-mining.

The United States Senate Committee on Irrigation sum up the legal relations of water and land as follows:

> The legal questions involved in the beneficial uses of water have been strangely complicated in California. The Indian community system prevailed before and during the Spanish occupation, having been made useful by the missionaries, who obtained such great control of that population. The Spanish conquerors were themselves original dwellers in an arid region. When the State passed under the control of this Republic, such small portions of it as were cultivated owed their fertility

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entirely to irrigation. The modes of distribution were recognized as being properly controllable by the community. Water was public property. The American miner, with his new enterprises and enormous energy, created a whole code of laws in regard to the use of water. Its basis was the pioneer principle of first come first served, and that has been reproduced in our jurisprudence as "prior appropriation."

In forming a constitution, the people of California incorporated the body of common law. Judges and courts have construed the common law to mean that the doctrine of riparian rights necessary in England and in our Eastern States should be applied to the use and distribution of water to agriculture. It is easy to see that this conflict of prior appropriation and riparian rights must create considerable trouble. A large majority of the earlier irrigation enterprises, generally found in the foot-hills region, were served with water secured under the miners' prior appropriation laws. When the land-owner on a stream demanded his riparian use of the flowing water, litigation or worse at once ensued. At no time, however, were the communities in the southern part of the State organized upon the old Indian and Mexican control involved in this dispute. The prior appropriations had often, it is charged, attempted to monopolize the water supplies, not for their own or immediate use, but for speculative purposes, and as a lien upon the future. This gave some color of equity to the absurd demands for riparian rights, as at times these were sought to be exercised by small land-owners against the large appropriators of water and owners of great tracts of land. A few years since the supreme court of California brought the subject of riparian rights to a crisis by deciding in favor thereof.

As a result of this conflict, California has adopted a plan of co-operative or district control which bids fair to wisely settle all questions of water and its use, of irrigation, construction, and ownership, and of the methods and forces by which these shall be managed and paid for. This is embodied in several legislative acts known as the "Wright Irrigation District Laws." Under these acts the people of any drainage and arable area to be supplied by water from a common source, can, by obeying certain legal requirements, form themselves into an irrigation district, having a common seal, the right to sue and be sued, to make, own, and control irrigation constructions, to issue bonds therefor and pay interest on them, to levy taxes, to meet indebtedness and maintain works, to regulate the use of waters and decide the cost thereof to the farmer and consumer, to condemn lands and water rights, and in short to do all things necessary for a civil organization. These acts have all been passed during the last four years.

The constitutionality of the bonds to be issued have been assailed, but were affirmed and sustained by the Supreme Court. Since then, action under the district laws has been progressing quite rapidly. Some twenty districts had been organized at the time your committee was in California. The bonds of several had been successfully negotiated. Since then, at least ten more have been set up in operation, the larger portion being in southern California. The amount of bonds involved ranged from $6,500 in a San Bernardino district to $3,000,000 in the district now forming in Fresno County. The area so far included will be over 3,500,000 acres. Probably one-sixth of this area is already irrigated.

Under the present system every water user first pays a royalty for the right to use of about $2,500, and thereafter an annual rental of $2.50 per acre. In condemning a ditch system, the district may under the law regard the royalties paid as compensation, to their full extent, of the original outlay. They will pay, therefore, for the ditches on the basis of their annual rental values. The proposed new works will have no charges to meet other than those legally established for the payment of interest, the repayment of the bonds, and maintenance of the district irrigation works.

As the area of reclamation grows larger each year, the annual taxation must necessarily grow much smaller to each individual. The cost under private or corporative ditch systems will certainly exceed at the end of twenty-one years that of the district system, by the entire amount of royalty the private enterprises would have exacted. And when the district debt should be paid off, the small annual cost for maintenance and repairs would be all that irrigators would have to bear.

EFFECTS OF IRRIGATION ON HEALTH.

There is another and very important question to be considered, and that is as to the effect of irrigation on the general health. In California considerable attention has been paid to this subject, and in 1884 a report on the subject was made by the State board of health. There are conflicting opinions in the report made by the board. In certain counties, as Ventura, Santa Barbara, San Bernardino, San Diego, irrigation has been employed for over a century, and the absence of malarial disease is noted, as well where irrigation is practised as where it is not.

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Other portions of California show a marked increase of malarial fever where irrigation is practiced. It is not difficult to discover the reasons for this. In Los Angeles and other valleys in extreme southern California, where the soil is, as a rule, sandy or gravelly loam of unknown depth, the water used in irrigating sinks into the ground or (on sloping surface) drains off immediately. It does not remain to saturate the soil unless there be a stratum of clay (hardpan) near the surface. In such sections of the country there is almost entire freedom from malarial diseases Along the bottom lands of rivers, and where the slope is insufficient to insure good drainage, or where the soil is saturated constantly, the case is different, and there are intermittent and remittent fevers during the warmer seasons of the year. The fact that the people living in these low, wet sections of country are dependent upon impure or surface water for drinking and domestic purposes aggravates the difficulty, for it has been demonstrated that people living in a fever-and-ague country are tolerably exempt from the disease if they drink only pure water.

From all portions of California letters from medical practitioners and other residents are in singular accord in saying that irrigation, when properly managed, does not produce any increase of malarial diseases.

IRRIGATION AND FRUIT RAISING.

The State Board of Trade reported in a careful paper that:

The peculiar productions of California is another reason why irrigation will soon be a great feature in our agriculture. California is situated quite differently from any other Pacific coast State or Territory. Indeed, many of the productions of its soil are peculiar to it. For instance, there are planted in California, according to authentic data, 50,000 acres in orange and lemon trees; all these must be irrigated. Last year there were shipped East for sale 1,850 car-loads of oranges and lemons, and about 600 car-loads were consumed at home. There are over 20,000 acres of olive trees planted in California. Most of these are not bearing; some of them are; but enough are in bearing to show that this remarkable fruit grows here with wonderful luxuriance and bears abundantly. The olive thrives nowhere else in the United States. Last year there were produced in this State 3,400 cases of olive oil, and of the very best quality. There are 140,000 acres of land now planted in grape-vines in the State of California; and for the year 1888 there were produced 18,000,000 gallons of wine, 20,500,000 pounds of raisins, and 1,000,000 pounds of dried grapes. These vines are the European varieties, which will not grow where the ground freezes; and they are not successfully cultivated in any other part of the United States. Both our wines and raisins are successfully competing with European productions. There are about 1,000,000 prune trees growing in California, outside of the acreage planted during the winter of 1888-'89. This most-needed fruit is not produced in the United States except on the Pacific coast.

In 1888 California produced 7,000,000 pounds of prunes, and it will be observed that there were imported into the United States for the same year, for consumption in America, over 70,000,000 pounds. In a very short time California will be able to supply the American market. There are 300,000 fig trees planted in California, and the figs produced here are of the very best quality. The trees grow luxuriantly and thrive well. It must be admitted that it is of infinite importance to our country to encourage the production at home of all these articles which otherwise we would be compelled to import.

In this connection it may be added that California is a great nut-producing country; the almond grows well and produces well. There are now over 25,000 acres of land planted in almond trees, and this acreage is yearly increasing. In 1888 California produced 180,000 pounds of almonds. The so-called English walnut is also a most valuable California nut, and grows well in nearly all sections of the State where the soil is deep or irrigation possible. No mention is made of the peach, the cherry, the pear, the apricot, the nectarine, the plum, or the apple. All these fruits are grown in California in such abundance that the mention of them seems unnecessary. Add to these fruits the whole berry family, conspicuous among them the strawberry, the blackberry, and the raspberry, and we may well observe the unlimited capabilities of this State for fruit culture.

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Its report presents the following facts, among others:

IS IRRIGATION ADVANTAGEOUS?

The advantage of irrigation is twofold: first, the water is applied at a time when it will do the most good, and when the ground is in such a condition that the grain or the fruit trees will get the full benefit of all the water that is run upon the land; and second, where irrigation is practiced there are no droughts. In countries where there is ordinarily an ample rain-fall, the crops often fail by reason of droughts. This arises from the fact that the rain falls in vast quantities, but at unpropitious times, when it does little or no good to the crops.

In California, from about the middle of May until the last of October, we have no rains. During this period grain is harvested.

The use of water is often more valuable for fruit growing than for small grains. We doubt whether the wheat fields of California will ever be irrigated, because fruit is more valuable and the irrigation of orchards is more readily accomplished than the irrigation of the small grains; and because, as a rule, in the great wheat-producing portions of California irrigation for the purpose of producing one crop of cereals is not necessary. But California is especially a fruit-growing country. Its adaptability to almost all kinds of fruit is peculiar. Perhaps no country in the world is its equal; and in some of the great interior valleys of the State, and also in the foot-hill counties, successful fruit growing can be made certain only by irrigation. With the orange and lemon irrigation is a necessity. Where orchards require irrigation it has been proved that to sustain the trees in their growth and fructification, water need not be put upon the land more than from three to five times during the summer and fall months. The practice is to run water in small ditches between the rows of trees through the orchard about once a month, commencing in June and ending in September. Then immediately after irrigating the ground, by allowing the water to flow through these small ditches, the practice is to put in the cultivator, stir up the ground anew, so that the evaporation will not be rapid, and the ground will not settle down and become hard. The land thus remains friable, and the trees grow with great rapidity.

The orchards and vineyards in the coast counties and in central and northern California have hitherto never been irrigated. Where the size of the grape is an especial and important factor, like in the making of raisins, the irrigation of the vines is advantageous, and especially where the vineyard is planted in very hot and dry situations, like at Fresno and Merced. Up to this time no grape vines nor orchards have been irrigated in any of the counties of Santa Clara, Alameda, Contra Costa, Solano, Sonoma, Marin, or Napa, and the fruit trees and the vines grow there with great luxuriance and produce abundantly; and yet in each of these counties vegetables and the smaller fruits, like strawberries, are now irrigated during some of the summer months.

THE AMOUNT OF WATER NECESSARY.

There will not be required the same amount of water for successful irrigation in California as is used in India. In India it requires about 1 cubic foot of water running every second to irrigate 200 acres of land to produce cereals. In Granada, Spain, where cereals are produced, 1 cubic foot of water running per second irrigates about 250 acres.

One inch of water running continually irrigates in southern California about 10 acres. Even less than this amount would be required in portions of central and northern California.

THE RESULTS OF IRRIGATION.

Los Angeles and San Bernardino Counties are conspicuous illustrations of what irrigation can accomplish. Nothing can picture the change which has there been made by means of irrigation. A great plain which once looked like a desert is now covered with beautiful homes, surrounded with orange orchards and vineyards, dotted with towns and cities, which have grown up everywhere as if by magic. The population has more than quadrupled in a single decade. Lands which sold ten years ago at from $5 to $25 per acre now sell at from $100 to $1,000 per acre, and these prices seem to be fixed from what the lands actually produce. Nor is this condition of things peculiar only to southern California. In Placer County water has for some years been used for the irrigation of orchards and vineyards there planted. It is impossible to describe the change thus created. Orchards of every variety of fruits, from the orange and lemon to the apple, and vineyards of every rare variety of grape, and nuts of all known varieties grown in semi-tropical climates, and the fig and the olive, all seem to flourish in the foot-hills of Placer County; nor does the result in Placer County seem to be peculiar to that locality, for everywhere in the foot-hills of the

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Sierra Nevadas, where irrigation has been introduced, the result has been equally surprising.

The foot-hill country about Oroville, in the county of Butte, where water has been introduced, is no less conspicuous for its luxuriant tree-growth. Within the last four years 1,500 acres of orange orchards have been planted, and these trees seem to be thriving well. The oranges are rich in color, luscious in taste, and attractive as to size. This is mentioned only to show the effect of irrigation upon both the foot-hill and valley lands of the State of California.

More marvelous still is that section of country lying about half-way between the extreme northern and southern part of the State. Within the past few years a town has been built there, which has a population of over 10,000; the surrounding country is cultivated in everything the farm can produce. Indeed, Fresno County is to-day the great raisin-growing center of the State, and nearly every variety of fruit grows abundantly. There a beautiful orchard stands side by side with an alfalfa or grain field. Homes are literally hid away by the remarkable ornamental tree-growth which irrigation has caused. Ten years ago the lands of Fresno sold at from $3 to $20 per acre; now the same land with water on it sells at from $75 to $750 per acre. This is all due to irrigation. Kern County is another conspicuous land mark on the road to successful irrigation; more than 80,000 acres of land is being irrigated in that county. The production is generally alfalfa.

Everywhere in California during the summer months garden vegetables are raised by irrigation. In the fall, winter, and spring months in most parts of the State they require no irrigation, except such as they get from the natural rain-fall. So with strawberries; this fruit is universally irrigated. In Santa Clara County alone it is claimed there are 1,500 acres of land cultivated in berries, all of which are irrigated; and that there are over 500 acres cultivated in garden vegetables, which are also irrigated. Even in northern counties like Napa, where the annual rain-fall is almost three times as great as in some parts of southern California, strawberries, other small berries, and garden vegetables during the summer months are universally irrigated.

IRRIGABLE AND STORAGE AREAS.

Large areas of plain or bench lands, lying above the bottom lands of the river, are to be found in Shatsa, Tehama, Butte, Colusa, and other Counties. They are all within reach of the water flowing down the Sacramento River and its lateral tributaries. Most of the streams emptying into the Sacramento from the Coast Range sink and disappear during the summer not far below where they debouch from the mountains into the open country; but at their sources there are large quantities of water that can be stored or impounded in the reservoir-sites that are available.

The irrigable lands of Lassen County, lying about 1,000 feet below these sources of water, are not far from 500,000 acres; and east of these lands, in the State of Nevada, is an area of like extent. The lands are rich, sandy loam, productive with water, but comparatively useless without. The climate of Honey Lake Valley is most delightful, being free from excessive heat and not subject to very low temperatures. Here is a region of nearly or quite 1,000,000 acres of public lands that can not now be settled upon, but are nevertheless capable of sustaining a large population. A rough calculation shows that in Eagle Lake there is stored enough water to irrigate 500,000 acres of land; and at the head of Susan River comparatively cheap reservoir sites are available to store water sufficient for a half million acres more. North of this region lies Madelin Plains, a large area of good lands if irrigated. In Modoc County like areas are lying idle and useless, yet are capable of high cultivation and of sustaining a large population.

Inyo County, Cal., is especially adapted to irrigation, particularly that part of it known as Owens Valley. From Olancha to the head of Round Valley is 100 miles; the whole of this distance, a strip of country from 4 to 6 miles in width, is susceptible of irrigation. There are from 300,000 to 400,000 acres of land of surpassed fertility which are utterly worthless without the use of water. It is claimed by experienced

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engineers that the Owens River carries on an average, and during the summer months, water enough to place at least a surface depth of 15 inches upon an area of 300,000 acres of land, and this without preparing catchment reservoirs. A large portion of this country is still a part of the public domain. Less than 12,000 acres of land are now cultivated in Owens Valley.

In the extreme southern portions of California there is ample opportunity for storage on a large scale. There is a difference of opinion among engineers. Some think there are many basins and cañons in the mountains which are adapted to the purpose, and others think these, on most streams, are wanting. Most, however, agree that the bench lands furnish abundant opportunities for the construction of reservoirs. There are a number of reservoirs of both kinds finished and in process of construction, of capacity varying from a few thousand to a billion gallons. One on Mormon Creek, in the rim of the San Fernando Basin, is of more than the latter capacity.

The number of acres of good land which require irrigation are, south of the mountains, according to the State engineer's estimate, 460,900. North of the Sierra Madre range, Los Angeles County shares with Kern and San Bernardino in the great Mojave desert, so called. This desolate region contains many thousand square miles. In these three counties one-half of this is probably arid beyond redemption; one-half of the remainder is too rough and mountainous to be valuable for cultivation, but the remainder is mostly highly fertile soil, lying favorably for the application of water. Of this vast territory, Los Angeles County possesses 250,000 acres, which can be made to comfortably sustain a population of 100,000 people.

It is stated that the lowest summer flow of the Mojave River is about 5,000 inches. The average flow for six months in the year, the winter and spring months, is from 20,000 to 30,000 inches; during May, June, and July more than 10,000, and for the rest of the season more than 5,000 inches. Of this the Hesperia Land and Water Company has filed a claim of 5,000 inches.

The land is mostly Government land, and the profits thereon would pay for enormous and elaborate works. Big and Little Rock Creeks, which debouch upon the desert plain at higher elevation, west of the Mojave River, are wholly within Los Angeles County. Their flow in winter is thousands of inches, and in summer is sufficient, as at present handled, to irrigate several hundred acres. Facilities for storage on these creeks are as abundant as on the Mojave. The land below is still owned, for the most part, by the Government. The universal testimony is that it is as fertile as the best. It is covered with grass and flowers during several months of the year, and is capable, under irrigation, of producing the most luxuriant and profitable crops. Artesian-well boring has proved successful in places on the desert, but the expense is of course greater than elsewhere. The region is one of the most healthful on the globe. Its hot, dry atmosphere is found congenial to many people. It is especially adapted to the production of certain crops, as the fig and raisin grape. It produces in some places as fine wheat as is raised anywhere, but to become habitable for any more than a few scattered families or small communities, it must have water to save its crops in summer. Value of irrigable land, $50 per acre; non-irrigable land, $1.15 per acre; the number of artesian wells in the region, seven, with an average depth of 340 feet and average flow of 12 inches. The counties of Los Angeles and Orange have an area of 4,812 square miles, or 3,079,680 acres. Their population is fully 150,000

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souls. Without irrigation not one-quarter of this number would be living there; and "this in spite of the fact that those two counties produce more than one-half of the corn of the State almost altogether without irrigation; that there are nearly 90,000 acres of good land that require no irrigation."

The land now irrigated is about 150,000 acres, and this is the basis of maintenance of 113,000 people. Theoretically, no increase of this population is wanted without a corresponding increase of irrigated lands. Factories and mineral developments, travel and transportation by sea and land, and the healthfulness and delightfulness of the climate, would add to the population; but the cost of living would be increased in proportion to growth, the homes of the poor would no longer be those of people who control their own destinies; and this would become a rich man's paradise—a thing not to be desired.

Ten years ago the population of the counties was little over 30,000. Fifteen years ago the land on which Pasadena now stands was held at $7 per acre; in seven years it was valued and sold in large quantities at from $500 to $1,000 per acre. This was for orchards—not city lots—orchards made possible only by a supply of moisture for the roots of the trees during the long arid season of the year. So with the whole of the great foot-hill region along the base of the Sierra Madre range from Tejunga and Crescenda Cañada on the west through Altadena, Sierra Madre, Lamanda Park, Santa Anita, Monrovia, Duarte, Ayusa, Glendora, Alosta, San Dimas, Lordsburg, Cucamonga, Rialto, Redlands, and over the San Gorgonio Pass into the desert at Indio, and again at Riverside and Arlington, and places too numerous to mention. The growth has been proportionate to the extent to which irrigation has been carried. The region mentioned was almost worthless even for grazing purposes, and was as incapable of sustaining a population as the Mojave Desert itself. Now visit it and you will find it the most charming region and the most valuable land in all California, or in the United States for that matter.

GROWTH OF ENTERPRISE AND VALUES.

In Fresno County there are 100,000 acres of land now irrigated. This estimate is made by Mr. George Manuel, a well-known civil engineer, but he adds:

"It is somewhat difficult to draw the line between irrigated and unirrigated lands, for the reason that the effects of irrigation by filling up the country affect and render fertile to a great extent lands lying contiguous to irrigated lands, but not themselves subjected to irrigation by the usual methods of application. Of this latter class of lands," says he, "there are about 200,000 acres."

Thus it will be seen that the 200,000 acres are an area double in extent of that which is actually irrigated, and is reaping the benefits without being subjected to any of the burdens of irrigation. Irrigation in Fresno County has heretofore been carried on wholly by the private canal system. It is a voluntary matter by this plan with each landowner whether or not he will contribute anything towards the expense incident to the irrigation of lands. His lands may be surrounded by irrigated lands, and thus in a short time they become sufficiently irrigated by percolation; but he may and does decline to buy water where he can get it by absorption without. By the district plan this iniquity is overcome; and every man who owns land that will be benefited is compelled to contribute his portion of the expense incident to the system, and gets in return all the water he may require.

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The following is the estimate made by Mr. Manuel of the amount of land in Fresno County which is now not irrigated, but which is irrigable:

	Acres.
(1) In Madera irrigation district, about	300,000
(2) Under Chowchilla Canal, excluding about 5,000 acres already irrigated.	60,000
(3) Land lying above or east of Madera district, but which can be irrigated by a branch of the main canal of said district (in Fresno County)	87,600
(4) Land lying above water in main canal of Madera district, but which is susceptible of irrigation by a system of storage reservoirs	38,400
(5) Land lying between San Joaquin and Kings Rivers, excluding about 60,000 acres already irrigated, and which can be irrigated by existing works or their extensions	684,960
(6) Land lying above or east of Enterprise Canal, but which can be covered by storage reservoirs or branch canal taken out high up in the mountains	40,000
(7) On west side of Fresno Slough, below Hall survey in Fresno County, which can be covered with extensive irrigation works	113,000
(8) In Sunset irrigation district above Hall survey, proposed to be irrigated by a canal having levees 35 feet high at highest point, and about 15 miles long, and which lie above Hall survey	190,000
(9) Between the 240 and 300 feet contour line on State engineer's map, which can be irrigated by canal taken from Kern River, or by water pumped by water power as proposed by Sunset district in Fresno County	190,000
(10) Land lying above the 300 feet grade line in Fresno County on west side, which can only be irrigated by storage reservoirs on the streams flowing from the Coast Range	293,000
Total	1,996,960

Mr. Manual states further that—

In 1870, in township 14 south, range 20 east, sections 1 to 5, assessed to W. S. Chapman, at $1.01 per acre; section 36, at $1.13 per acre; that made an assessed valuation of that township, in 1870, of a little over $25,500 in round figures. In 1880 the Bank of California tract, a portion of these twelve sections, at $4 an acre, and Bank of California tract, 240 acres, at $5 per acre. C. A. Towne, section 2, adjoining Fresno City, at $5 per acre. C. H. Hoffman, section 12, near Fresno, at $5 per acre. E. Jansen, six sections near Fresno City, at $4 per acre. In 1888, A. T. Covell, in Washington Colony, 5 miles from Fresno, 60 acres, at $150 per acre. Sections 1 and 2 and 11 and 12 at $250 to $300 per acre, $250 per acre being about the average for unimproved land. And this increase in the value of land is due to irrigation. It is the same land exactly, only in different years, as irrigation has progressed.

Sections 6 and 7, at $100 per acre; section 19, at $75 per acre; sections 5 to 8, unimproved, and from one-half to 1 mile from the city of Fresno, at $125 and $200 per acre; sections 17, 18, and 19, averaging $85 an acre, and sections 23, 24, 25, and 26, at $75 per acre. That is the valuation of that township. The first assessment was $25,500 in round numbers, and the last assessment of the city, $6,800,000. And the total valuation of that township is probably in the neighborhood of $9,000,000. Concerning the value of irrigation, I know of one canal that was said to cost in the neighborhood of $50,000. The first year after its inception the increased value of the real estate along the line of the canal was $640,000—land that could before have been bought at $2.50 per acre had increased in value sufficient to make that valuation. So I could give other instances, but I suppose that would be sufficient.

Mr. Thomas Hughes, well known as a real estate operator, also testified that—

In 1881 I purchased 7,000 acres of land adjoining the town of Fresno, agreeing to pay $40,000, and having 6 months to make the first payment of $5,000. I immediately had circulars printed, offering to sell land, with water for irrigation, to parties who would move on the land and improve in trees and vines, without any cash payment. In this way I soon sold the most of this tract, and would borrow on my note with these mortgage notes as collateral security, getting about 50 cents advance on the dollar. I sold the land at prices ranging from $40 to $75 per acre. This gave me a surplus of money to pay what I was owing on the land, and money to make a small payment on the purchase of other lands, which I continued to do from year to year, until I was myself $350,000 in debt, and had mortgage notes due me to the amount of nearly $500,000 for lands in most cases sold on a credit of one, two, and three years, with interest at 10 per cent., payable half yearly. The settlers have all made their

places worth to-day from $200 to $1,000 per acre, and all have paid me in full. I have sold thousands of acres of land on these terms, and I have never been compelled to foreclose a mortgage in Fresno County. Men who will work can settle on irrigated land, pay their 10 per cent. interest, improve the land, and pay for their land at prices ranging from $50 to $125 per acre inside of four years. And that, too, on land that before the irrigation system was started could not be sold for more than from $1 to $5 per acre, according to location.

In Tulare County much progress has been made in the work of irrigation. The one criticism to be made on the work in that section is that it is fragmentary and lacks uniformity and systematic methods. Irrigation is consequently patchwork, but enough has been done to demonstrate the miraculous power of irrigation in the San Joaquin Valley.

Mr. P. Y. Baker, civil engineer, for many years devoted to the work, says: "There are about 15,000 acres irrigated in this county, and 950,000 acres not irrigated. There are about 250,000 practically useless without irrigation. Of the above 950,000 there are perhaps 700,000 that produce some crops without irrigation, but very little of it produces fair crops. That is to say, one year with another, the average would be so low that it would be a serious question of making a bare living on most of it. Experience has shown that the proximity of irrigation has added much to the productiveness of non-irrigated lands."

In Merced County provision has been made whereby a considerable area of lands may be irrigated; but the acreage actually subjected to irrigation is small. The Crocker Canal, which is said to have cost $1,500,000, is situated in this county, and will eventually be applied to a large area. The area of the plain lands which may be profitably irrigated is large. So far as irrigation has become an accomplished fact in the San Joaquin Valley, it has been done through private enterprise. Under the district irrigation law of 1887 a number of irrigation districts have been organized, and by this means the irrigated area will soon be rapidly extended. Twelve irrigation districts are reported as organized or in process of organization within the valley of the San Joaquin. The total acreage involved is estimated at 2,000,000; the total amount of the bonds to be issued will not be less than $10,000,000. The area of the following irrigation districts can be given with accuracy:

Modesto	acres..	108,000
Turlock	do...	176,000
West Side	do...	300,000
Madera	do...	330,000
Alta	do...	160,000
White River	do...	60,000
Poso	do...	48,000
Sunset (proposed)	do...	285,000
Fresno (proposed)	do...	300,000
Total area San Joaquin Valley		1,767,000

The total area irrigated in the same section was given by State Engineer in 1885, at 251,140 acres. This area has certainly increased one-fourth, and would therefore be not less than 313,670 acres. It is probably nearer 350,000.

LOS ANGELES COUNTY.

The irrigable portions of Los Angeles County are embraced in the San Gabriel and San Fernando Valleys and the coast plain region. The San Gabriel Valley is 23 miles in length, east and west, 11 miles in width, north and south, with a broad outlet somewhat west of the

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middle point on its southern side. It is but little less well-defined as a basin than that of San Bernardino. At the lowest point on the higher side of the valley, next the mountain base, 11 miles north and 2 miles east, the elevations range from 625 to 675 feet. At the extreme northwest corner they are between 1,500 and 1,700 feet, and at the other extremity of the valley, next the mountain's base, the plain is 1,000 to 1,100 feet above the sea.

Together with its mountain and hill-side catchment areas the San Gabriel Valley embraces a territory about 560 square miles in extent. The mesa, benches, plains, washes, and bottoms composing the valley itself cover nearly 200 square miles, or about 123,000 acres. Of this amount about 92,500 acres are highly cultivable and productive lands, but requiring irrigation.

The San Fernando Valley occupies the western portion of the Southern California basin. It contains about 570 square miles. Of this area there about 100,000 acres of really good irrigable lands. The coast plain embraces an area of 1,472 square miles. Of the total, leaving out hills, marshes, wet land, and 68,000 acres requiring irrigation, there are about 270,000 acres fit for cultivation by irrigation. It is all below 500 feet in elevation.

The rule as to distribution of rain-fall, as affected by the mountain ranges, is emphasized in Los Angeles; the heavy down-pour is on the slopes of, and on the plains and bench-lands at the base of, the ridges, on the side next the direction from which the storm clouds are brought.

On the coast plain and elsewhere on the lower elevation the down-pour reaches about 15 inches per annum. In the San Fernando Valley, from other causes, it falls to about 11 inches. At the base of these mountains it rises to 15 again, and at Ravenna it falls to less than 11 inches, though the elevation is 2,300 feet above the sea. But as the base of Sierra Madre is reached, the precipitation reaches 22 inches, though the elevation is but 700 feet. On the mountain bench-lands the rain-fall is from 50 to 100 per cent. greater in the valley, but 10 miles distant and but 600 feet lower.

Of the irrigable portions of this county, the San Fernando Valley and the coast plain are materially the driest sections, and the bench-lands and mesas, at the bases of the Cahuenga and the Sierra Madre, receive much the greatest rain-fall. San Gabriel Valley, as a whole, probably receives 50 per cent. greater rain-fall than does the San Fernando, and 80 to 90 per cent. more than does the valley of San Bernardino. The reasons for these differences are found in the following facts: San Gabriel Valley has no high mountain range in front of it, and has a high range immediately back of it. San Bernardino Valley, notwithstanding the fact of the higher range behind it, has also quite a high range in front. San Fernando Valley has a moderately high range in front of it, and only a moderately high range behind it for more than half its length.

The streams all lose their waters in the underlying gravels, within a few miles of their cañon mouths, during fully eight to ten months (including the irrigation months) of almost every year. All but two or three of the larger cañon streams do not, naturally, even bring their waters outside the cañon mouths, for six months of almost every year. The waters are lost in bowlders and gravels, but they reappear below in the springs and *cienagas* of the Los Angeles Valley, or in those of the San Gabriel basin. There are two classes of streams, then, serving irrigation in this region—those which have their independent mountain drainage areas, and come to the interior valley through deep gorges or cañons, and then sink; and those which rise at the outlets of the three

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main divisions of the interior valley, namely, the Los Angeles, Lower San Gabriel, and Lower Santa Ana Rivers.

There are eleven principal groups or systems of irrigation, the San Gabriel and San Fernando basins being again subdivided into as many more. The description of San Bernardino works will serve largely for those of Los Angeles County. The artesian-well groups are numerous, and their economic use is an entire and extended success. Sub-irrigation by iron and cement conduits is a great feature, four systems alone using 240,013 feet, of which 3,005 feet are of iron piping. There are also 3,607 feet of cement canals. The cost was $275,000, $90,000 of which was for well-boring and water development. These systems belong to the Pomona group of fruit colonies. In practice, a fixed and uniform rate of 10 cents per hour for a run of water is charged, as a *zanjero's* fee, each time a head of water is turned on to an irrigator. The "heads" used in irrigation are 30, 45, and 60 inches in volume, but the rate charged is the same for all, so that the double volume afforded by the 60-inch head costs no more than that afforded by the head of 30 inches, for the twenty-four hours. The actual cost of water to the irrigators per acre ranges between 72 cents and $1.92, and averages about $1.30 per year.

There are in Los Angeles County a large number of settlements made on the colony plan, and a more considerable area occupied by large and small ranches, vineyards, and orange groves. The water system, serving the city and for domestic as well as neighborhood and irrigation use, is as typical as anything in the land, being based on the old Spanish-Indian community plan, as modified by modern use and growth. The *zanjas* have a total service and length as follows:

	High and low service.	
	Feet.	Miles.
Open earth ditches	140,135	26.5
Cement pipes or conduit	91,490	17.3
Iron pipe	28,836	5.5
Wooden flume and tunnel	15,900	3.0
Total	276,361	52.66

This summary shows that the total length of conduits maintained by the city is 52.3 miles, of which 25.8 miles, or nearly 50 per cent., consists of tight conduits—wooden flumes, cement and iron pipe, cement or masonry-lined canals, brick culvert, etc.—and the balance consists of open canal and ditches of various kinds and sizes.

There are 40 miles of ditches outside this system, but receiving their water supply from the city zanjas, making in all over 93 miles of conduit, connecting with as many more miles of private distributory ditches and pipes. The cost has been during the past fourteen years about $300,000.

The irrigation system of Los Angeles is under the direct control of the city council, from the heads of the zanjas on the river to the southern limits of the city, and from there on the distribution is managed by several associations of outside irrigators.

The council appoints a general zanjero, or ditch overseer, and assistants, fixes the rates for sale of water, orders all zanja improvements that are made within the city, and maintains entire control over diversion from the river. In times past the council has apportioned the

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water to the land within city limits at the rate of an irrigating head for twenty-four hours to one acre for every thirty days. This was when the acreage irrigated inside the city limits was greater than it now is. This city allotment is now, however, a dead letter, as the inside irrigators have more than they require, and the council has no concern for distribution of the water after it leaves the corporation limits. Every individual irrigator whose lands are inside the city bounds is allowed all the water he wishes to buy and pay for without restriction, and the surplus waters are sold to the outside associations.

Outside the city limits the irrigators are organized in regularly defined districts on the extension of each zanja. These districts abut on the city, and when organized were considered to embrace all lands which could be reached by the spare water of the river. Some of them have been much extended, however, and in one or two instances secondary districts subject to and buying water from the primary districts are found adjoining the latter. With the improvement of the zanjas and the diminution of cultivation within the city the irrigable area has extended year by year, and is now carried even beyond the secondary outside districts. The outside organizations are incorporated associations of irrigators, which elect officers, are governed by sets of by-laws, and appoint zanjeros, whose duty it is to purchase surplus water of the city and sell it to the irrigators, each of his own district, at a premium fixed by the association, which constitutes its compensation.

Water is sold by the irrigating head in measure of time. The rates, always subject to change, are at present in the city $3 per head per day (sunrise to sunset); $2 per head for half day (sunrise to noon, or noon to sunset), and 50 cents per hour. Current rates charged the outside districts by the city are $5 per head per day, $3 per night. Single hour permits are not sold outside. These rates are 50 per cent. higher than they were two years ago. In 1880 the city rates were per day $2; half day, $1.25; night, $1.50. In 1873 they were $1.75 per day, $1.25 per half day; $1 per night, inside city limits. Outside they were $3 per day; $2 per night. In 1870 in the city they were $1.50 per day and $1 per night from March 1 to October 1. After the latter date 75 cents per day and free at night.

The area irrigated under this system is about 12,000 acres, of which nearly 3,000 is within the city limits.

Engineer Hall mentions in his last report 250 different systems of irrigation works within the three southern counties of California; also 18 different artesian water and well basins, the total acreage of which is large.

SAN BERNARDINO COUNTY.

Mounts San Bernardino and Grayback are the culminating points in the topography of southern California. From them, trending southeast, start the San Diego ranges, which enter Mexican territory. Extending west, the Sierra Madre ranges reach away over a hundred miles through Los Angeles and into Ventura County. Standing at the meeting of these masses the San Bernardino peaks are the highest and most commanding objects in the landscape, and play a very important part in modifying local climatic phenomena and regulating irrigation water supply.

From the northwestern end of the San Diego range, or plateau, begins what is known collectively as the Coast Range, extending northward into and beyond Los Angeles County. Its face to the sea is a sloping

plain or mesa. East of this range and between it and the Sierra Madre lies the smaller counterpart of the great San Joaquin Valley to the north of it. From the coast to the San Bernardino Peak westward is a distance of 110 miles. Broken by two small, low groupings, it comprises the most valuable fruit region of the State. Within this area will be found at least 100 colony towns and villages; the growing and prosperous city of Los Angeles, and a population of over 250,000 persons, all of whose prosperity depend upon irrigation. In Los Angeles County the coastwise mesa becomes a broad alluvial plain. Engineer Hall, in his volume on irrigation in southern California, says:

North from the Sierra Madre chain stretches away to the Sierra Nevada mountains, a distance of over 50 miles, and from the Colorado River on the east to the Santa Barbara Mountains on the west the desert plain of the Mojave, comprising an area of 15,000 to 16,000 square miles. On this broad plateau there are extensive tracts of rich soil; but from the want of rain they are barren, and from the absence of water supply they are, except in very limited localities, non-irrigable. The Mojave, then, is not, save in a very much restricted sense, a part of the irrigation field present or prospective, although locally irrigation flourishes there and many small utilizations of water remain yet to be carried out.

It is the Sierra Madre range of southern California which, passing through Los Angeles and San Bernardino counties, constitutes a mountain wall, that, intercepting ocean breezes and storm clouds, precipitates their moisture upon high and rugged peaks, thereby regulating climate and making possible that high degree of cultivation which is necessary for successful horticulture.

The effect of an intercepting mountain range upon rain-fall is most distinctly marked in this region. The San Bernardino section offers no gradations as in San Diego. The clouds drifting inland from the sea are broken on the summits of the Sierra Madre and precipitate their contents upon its bald slope. They cover the crest with snow, and send great rains down the western slopes in heavy torrents. The valley below will have a rain-fall of barely 8 inches per annum. The mountain peaks and spurs above will receive from 70 to 100 inches in the same period. The slopes are exceedingly steep.

The accumulation of vegetable molds and soils, which are recognized as water-holding, are limited in extent. In an earlier geological era the rain-fall was immensely greater. Vast mountain torrents in those days poured through the cañon, carrying great masses of bowlders before them. The operation of the forces thus created have made deep bed-rock cuttings that are now filled with masses of broken matter. Into these flow and disappear the waters that pour from the mountains above. In this wise the artesian waters of the San Bernardino basin are collected.

The Santa Ana River, with an independent mountain area drainage of 220 square miles, is the main surface drain of this irrigable region and also its chief irrigation feeder. There are some twenty smaller and tributary creeks, cañons, or washes. In addition to these drainage areas the northern face of the San Bernardino range is drained by the Mohave River. The basin slope from east to west is about 26 miles in length, and comprises 120 square miles in all. Its future importance in irrigation is considered large. At present it is lost in the sandy waste 40 miles from its source. Engineer Hall classifies the San Bernardino lands as follows:

(1) The wet and marshy lands of the San Bernardino and Rincorn artesian basins, and the Chino; (2) the moist and semi-moist lands bordering the wet lands of the Rincon on the north, and bordering those of the San Bernardino on the north and east; (3) the moist bottom-lands bordering the Santa Ana River in its course through the Jurupa from the upper to the lower basin; (4) then, going to the other extreme,

the bone-dry red mesa lands, which fringe the entire valley more or less completely; (5) the bowlder and cobble-filled alluvions, which form the ancient dumps of the cañon creeks, and which, along the base of the main mountain range, to a great extent take the place of the red mesa lands; (6) the intermediate plains—dry, sandy, frequently gravelly, and with broad "washes" in parts, but in others with fine, light, rich, and deep soils.

The topographical features of the basin, with its great slopes in the ground surface ranging from 30 to 120 feet per mile, renders impossible any system of irrigation by "cheeks," such as is practiced in the San Joaquin Valley. It also compels the grouping of irrigation works and areas, deriving their supplies from limited and distinct sources. Three of these groups, embracing a large number of small works, obtain their supplies by diversions from the Santa Ana River or its main tributaries. Four other groups are fed from mountain cañons, the waters in which are derived mainly from subsoil supplies in the strata already described. Other groups obtain water by means of artesian wells, by tunnels driven into the mountain and securing thereby the drainage waters by lifting the sub-water of the cienagos or wet plains, or by other sub-dam works, raising to the surface supplies that would otherwise be lost. It is estimated that the great storage project of San Bernardino County, the Bear Valley reservoir, will very materially change the irrigation possibilities, or greatly enlarge the area of land under cultivation.

The value of water has enormously increased. The North Fork Water Company, which is under guaranty by the Bear Valley Reservoir Company, sold in 1865 at the rate of $30 per share, the water being valued at $18 per inch. In 1880 the value per share was $50, and that of water $26.40 per inch. In 1885 the value per inch of water was $360, and in 1888 $720. In another enterprise $40,000 is reported to have been paid for perpetual right to one cubic inch of water. The South Fork Canal valuation is given at $6 per miner's inch in 1872, and at $615 in 1887.

The different sources of supply, and the character and extent of areas served, compel as great a variety in the systems of distribution. One of the most notable of these systems is that made by tunneling into the mountain cañon walls and securing the drainage waters that pass through them. At Redlands, one tunnel delivers about 30 miner's inches, another about 130. The Ontario Colony enterprise, whose engineers, the Chaffee Bros., have since become known all over the world by their connection with great Australian projects, is the most famous of these tunnel works.

The water company at Ontario, after conserving all the surface supply by means of cemented canals and underground pipe-line, have driven a tunnel into the gravel and bowlders of the cañon bed a distance of 2,850 feet. Nowhere in the world is the duty of water so high as at Ontario. The supply is less than 800 miner's inches per annum, of which the tunnel will furnish from 50 to 60. The whole distribution is conducted through cement pipes. The work of distribution is in charge of a *zanjero*, or watermaster, who delivers water to each irrigator in heads of thirty inches for twenty-four hours each thirty days, for each ten acres owned, which is equivalent to a continuous flow of one inch to ten acres. The secretary of the company and the *zanjero* are the only regularly paid employés, but laborers are at times employed to work under the *zanjero's* direction in caring for and repairing the works. The cost of assessment for maintenence has not exceeded, so far, more than 70 cents per acre. The duty of water is claimed to range as high as one inch to ten acres; it is probably about one inch for seven acres.

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The Riverside Colony enterprise and its associates are the most prominent and best known of the fruit colonies in southern California. The works of the Riverside Water Company consist of three main canals and diversions, an extended irrigation distribution system, and a main pipe-line, and branches for the delivery of water, chiefly for domestic purposes.

The supplies are derived from the Santa Ana River and Warm Creek, and from an extensive system of artesian wells. The canal works are thoroughly constructed, provided with 2,400 feet of main flume, dams, head-gates, waste-gates, regulators, measuring-boxes, etc., having a total length of 33 miles of main canals and 50 of laterals. The area of Riverside proper is about 7,000 acres. With other and adjoining enterprises, the total area in the Riverside group will be 26,000 acres. It is the largest single orange-growing section in the State, and is second only to Fresno for raisin vineyards. In 1870 the land was assessed at 75 cents per acre; every acre of it will now average from $800 to $1,000. Originally begun as a land colony or co-operative enterprise, the projectors designed to keep the water supply separate as a continued source of income. Great dissatisfaction followed that plan. The land and water supply now go together. The entire cost of works within the old colony bounds, including legal expenses, is about $500,000. This does not embrace the domestic pipe-line supply. The cost of maintenance is about $30,000 per annum. There is a deficit between receipts and expenditures, however. The number of irrigators is about four hundred; acres owned by them, 6,500. The average holding is 16.12 acres; the highest acreage in one holding is 196. The cultivators of citrus trees is 360; number of vine-growers is 260. The average irrigated holding is 15 acres.

SAN DIEGO COUNTY.

The extreme southern division of California is one of the most remarkable of the arid areas within the Union. Along its eastern borders for a hundred miles or more flows the Colorado River, whose turbid waters drain from the heart of the continent. In comparison with all other water-courses it is a mighty flood, the greatest river of the Pacific coast, the Columbia alone excepted, flowing on undisturbed to the sea, past a vast desert which now challenges the power of man to utilize it. Nearly all of California that slopes toward the Colorado, and drains into it, if there be any drainage from a region so seldom and so sparingly visited by rain, is an absolute desert, within whose limits is included nearly three-fourths of the entire area of San Diego County.

The remainder contains the arable portion. A series of mountains separate it from the desert; their axes are generally parallel to the trend of the coast and distant from it 60 to 80 miles. These mountain masses, looked at from sea, do not form a continuous high chain or range, but a succession of peaks and ridges along the upper margin of a sloping plateau. This reaches an altitude of 4,000 to 5,000 feet, and the peaks and spurs maintain an elevation of 6,000 to 6,500 feet, and in one instance, that of San Jacinto Mountain, nearly 12,000 feet.

San Jacinto descends without a break to the edge of the desert basin, whose center is over 300 feet below sea level. Towards the ocean, the slope is gradual and open valleys are met with whenever the contours permit. The coast line is marked by a broad mesh or plain rising from 50 to 200 feet in the first mile, and continuing from 5 to 15 miles until it reaches an altitude of 5,000 feet, where it blends

into the ranges. Immediately beyond and generally lower in elevation will be found a series of land locked-valleys drained by separate waterways that cut their courses deeply to the sea. These valleys are becoming the seat of important irrigation enterprises. The mountain landscapes to the east are more attractive and gentle in outlines than those of the Sierra Madre in Los Angeles County or the more ragged aspects of the San Bernardino range. San Jacinto rises to an altitude of 12,000 feet, and by that fact compensates for an extreme aridity produced by the intervention of other mountain ranges to the south and west, which break the course of the rain clouds. The precipitation on San Jacinto, owing to its heavy snows and the lateness of their melting, maintains the flow of streams and springs by which the plains are in a large part supplied.

The streams which drain the western slope of the county seldom flow continuously to the sea during the dry months of summer and fall. The volume of their flow depends, in each case, not so much on the area as on the altitude of their water-sheds. Precipitation over the country is in a marked degree proportional to altitude; least upon the coast, greatest upon the mountain tops. This rule of proportion is very potent in its effect upon irrigation water supply.

The country is naturally divisible into three rain-fall belts, the first of which comprises all the mesas and valleys adjacent to the coast below an elevation of 1,000 feet, and covers an area of about 1,113 square miles. Within this belt are by far the greater portion of lands irrigable that require irrigation, and the greatest area which is generally free from frosts. The rain-fall in this belt is unreliable in character, subject to great fluctuations, the records showing that thirteen years out of twenty-three the rain-fall was less than 10 inches, and during five years was less than 6 inches per annum, while, with one exception, it never exceeded 16 inches. The effect of altitude is made quite plain by the fact that at Poway, 550 feet elevation, the precipitation in 6 years shows an annual average of 17 per cent. greater than on the coast, while at a further elevation of 200 feet more this rain-fall was 42 per cent. greater than at San Diego.

The second belt, an area about 1,400 square miles, has an elevation of from 1,000 to 3,000 feet. The rain-fall is estimated at from 18 to 24 inches. Ex-State Engineer Hall, who is the authority for these statements, puts the rain-fall at from 14 to 20 inches per annum.

The third belt, lying above an altitude of 3,000 feet, has a climate similar to that in some of the Southwestern States, except that summer rains are very rare and light, and the snows of winter not so deep nor long-continued. Its area is about 1,654 square miles, of which, perhaps, three-fourths is less than 4,500 feet in elevation. There are many fertile valleys, heavily-wooded slopes, and a small area of commercial timber within its borders. The rain-fall of this section is often in excess of its tillage duty. It is in this region that the great storage reservoirs must be constructed. The larger streams of the coast all head in it. There are eight of these in the county of San Diego having a total water-shed area of 3,567 square miles. In the first belt the water-shed is 630, in the second 1,282, in the third 1,655 square miles. The higher part of the mountain plateau and northern slopes of its ridges and peaks are wooded with varieties of pine, oak, and madroña. The upper cañons and valleys have sparse growths of oak, laurel, aspen, and madroña. The main ridges and frequently the northern slopes and lesser spurs are covered with dense low growth, commonly known in California as chaparral or chemisal. Along the streams—in the medium range of valleys—there are growths of cottonwood and willow,

principally; and along the main streams and on the sandy bottom-lands adjacent to them, similar vegetation abounds, in some places quite densely.

But the entire coast mesa, the broadest parts of the river valleys, the large valleys just within the line of the mesa formation, the greater portion of the plateau region, and a considerable portion of the mountain ridges are treeless and devoid of vegetation, such as is generally thought to conduce to the conservation of waters for the supply of streams. The light rains are all absorbed; and up to a point where the ground becomes well saturated there is but a small flow of surface drainage water finding its way to the rivers; but when this point of saturation is reached, then a large proportion of the waters of precipitation are shed off, and torrents form, which rush to the main drainage lines, and contribute to sudden and excessive freshets in those streams, carrying great loads of sand and finer sediments. The rains ceasing, and there being but a small amount of snow to melt, on a limited mountain area, the streams soon run down.

For reasons given heretofore, there are no large springs or areas of summer drainage of living waters. This, then, is a country where, in the aggregate, an amply sufficient rain-fall may be had to supply an abundance of water, but where, for the most part, it runs uselessly away to the sea. It is pre-eminently a country where the storing of water on a large scale is necessary to maintain any great irrigated area.

The irrigation systems practiced in San Diego County comprise the simplest known, being such as the Indians and Mexicans are accustomed to, as well also the most scientific and thoroughly well organized plans known to irrigation engineering. Several of the largest reservoirs that have been constructed are now in operation. Flume projects have been completed or are under way involving daring irrigation engineering. The reclamation of the irrigable territory of San Diego County, comprising an area of at least 450,000 acres, depends upon the degree of success with which the waters of six streams and the storm supplies above may be conserved by extensive reservoir systems. These rivers are the Tia, Juana, with five small valleys; the Sweetwater, with the same number; the San Diego, the San Diequito, and the San Luis Rey, with three valleys each, and the San Jacinto, with the Hemit Valley. In the first drainage system eight reservoir sites have been selected, with two great conduit flues connected with them. The Otay River projects comprise two large dams and reservoirs, having a capacity of 1,100,000,000 gallons.

The Sweetwater River system is the most extensive of all. Mr. Hall says:

> The engineering works would be notable in any country, and the lesson which the enterprise is working out on the subject of large storage reservoirs for the conservation of winter water for summer irrigation in this dry country is already highly instructive. It is now looked to with satisfaction by San Diegans as a type of what may be accomplished, under even unfavorable circumstances, upon nearly all the streams of this region.

The Sweetwater dam, a short distance above National City, is one of the boldest pieces of engineering in the country. The dam is constructed as a crown arch, and it is the largest of its character in the world.

The San Diego Flume Company proposes a system which, when completed, will consist of a storage reservoir, a diverting masonry dam, and a line of flume 36 miles in length. The method of distribution will probably be by pipes under pressure or by pipe cement channels. The Cuyamaca reservoir, 43 miles northeast of San Diego, covering 1,000

acres and having a full capacity of 499,880,930 cubic feet, is the chief dependence of this system. The diverting dam has a maximum height of 34.5 feet and a length of 447.5; the width of base is 18 feet and the top is 5 feet. The flume has a full length of 36.6 miles. The main pipe line will have a length of 9 miles. A branch pipe will be 1 mile in length and enter the main city reservoir, which has a capacity of 761,000,000 gallons and covers 100 acres. The cost of these works will be a little less than $1,700,000.

The Mission Valley Storage and Delivery Works will embrace eight reservoirs having a total storage capacity of 9,002,000 gallons. The San Diequito system will consist of a reservoir with masonry dam 80 feet high, 400 feet long on the crest, 170 on the bottom, with a capacity of about 3,000,000,000. There will be a second reservoir, with a capacity of 2,000,000,000 gallons, connected by an iron pipe of 30 inches with the upper one. The San Luis Rey flume provides for the construction of a mammoth reservoir dam, a canal from the cañon of the river some miles below, extending about twenty miles along the mountain and rolling hill-sides south and west of the river, and a secondary storage reservoir at the terminus of the canal in Bear Valley at an elevation of 1,300 feet. From this commanding elevation, but 20 miles from the sea at the nearest point, and 35 miles from the city of San Diego, the territory that may be served is only limited by the supply of water available. Pipe lines are projected in various directions. The main conduit drops into this secondary reservoir with a direct fall of seven hundred feet, and the utilization of this water-power and transmission by electricity to points of use are contemplated.

The Temecula Cañon storage reservoir will have control of 800 inches of running water besides its storage capacity. The same will be distributed by means of 10 miles of flume and 2 miles of iron pipe over a considerable irrigable area. The Hemit Valley system is quite extensive; its principal reservoir will be at an elevation of 4,300 feet, 20 miles above the town of San Jacinto, and in a most favorable location. Its largest reservoir surface will be nearly 600 acres and its capacity will then be about 6,000,000,000 gallons. These comprise the modern projects and systems west of the Colorado Desert, in San Diego County. There is a considerable area served by the old style, neighborhood ditches, and by means of wells from which the water is lifted by windmills. In the desert itself, at the eastern base of Mount San Jacinto, a town has been laid out and 6 miles of railroad constructed to connect with the Southern Pacific at the Seven Palms station. The flow of the White Water River is appropriated, and some 200 acres are laid out in orange trees. This is in the desert region proper, and it is probably the forerunner of many similar projects. That any extensive scheme for the reclamation of the desert as a whole will be attempted for many years is hardly probable.

THE STATE ENGINEER'S OFFICIAL DATA.

The following summary was made by Engineer Hall in 1888, and presented to the United States Senate Special Committee on Irrigation in the summer of 1889:

Area irrigated in San Diego County, 1888.

	Acres.
San Diego and San Diequito Rivers	360
San Luis Rey River	480
San Margurita River	312
San Jacinto River	965
Total	2,117

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Area irrigated in San Bernardino County, 1888.

	Acres.
Santa Ana River irrigations:	
Santa Cañon:	
Group	4,435
Basin diversion:	
Group Riverside Mesa subgroup	7,686
South side Santa Ana subgroup	799
Warm Creek subgroup	1,353
Lytle Creek and City Creek subgroup	384
North side Santa Ana subgroup	881
Jurupa Valley group	1,202
Rincon group	933
San Bernardino Valley irrigations:	
South Cañons group	1,466
North Cañons group	1,590
Cucamonga Plains irrigations:	
Cucamonga Plains group	5,361
Total for all groups	26,070

Area irrigated in Los Angeles County, 1888.

	Acres.
Cucamonga Plains irrigations:	
Pomona group	5,375
San Gabriel Valley irrigations:	
Sierra Madre Cañons group	
San José subgroup	225
San Gabriel River subgroup	5,150
Santa Anita River subgroup	350
San Pasquel subgroup	765
Basin group	7,590
San Gabriel and San Fernando group	1,550
San Fernando Valley irrigations:	
San Fernando group	4,875
Los Angeles Valley and Coast. Plains irrigations:	
Los Angeles group	13,987
Coast Plains irrigations:	
Cahuenga-Ballona group	1,535
Lower San Gabriel group	15,600
Lower Santa Anita River group	21,000
Santiago Creek group	2,100
San Juan Capistrano group	800
Total for all groups	80,902

Area irrigated in the three lower counties, 1888.	Acres.
San Diego County	2,117
San Bernardino County	26,070
Los Angeles County	80,902
Grand total	109,089

This area has increased by at least one-third since 1888.

Sources of and areas irrigated in the San Joaquin Valley. *

[*Summary for* 1885.]

Supply from—	Name of canals.	Irrigated area.
		Acres.
Kern River	Kern River canals	63,365
Poso Creek	Poso Creek canals	400
Deer Creek	Deer Creek canals	1,635
Tule River	Tule River canals	8,075
Kaweah River	Kaweah River canals	33,371
Kings River	Kings River canals	99,571
San Joaquin River	San Joaquin River canals	31,795
Fresno River	Fresno River canals	5,766
Chowchilla River	Chowchilla River canals	890
Merced River	Merced River canals	5,946
Tuolumne River	Tuolumne River canals	50
Stanislaus River	Stanislaus River canals	184
Mokelumne River	Mokelumne River canals	112
Total		251,140

* The area has been increased by at least one-third.

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PRODUCTS AND THEIR VALUES.

California is estimated to now have a population of over 1,200,000, of which one-third is found within the semi-tropical and southern portions of the State. Another third or more is found in San Francisco. Ten counties will contain over one-half the population.

The immigration increase in 1889 was 30,557.

In 1889 the California wheat product was 42,000,000 bushels.

Value of wheat	$32,000,000
That of fruit	16,000,000
Barley	9,000,000
Cereals unspecified	7,500,000
Wine and brandy	8,000,000
	72,500,000
Out of a total of raw products that include gold, silver, coal, etc	144,704,000
This leaves a balance of	72,204,000

The entire agricultural products of California since 1848 have been as follows:

Wheat	$732,000,000
Dairy	200,500,000
Barley	184,000,000
Wood	161,000,000
Fruit	106,000,000
	1,383,500,000

California—1888–'89.

	Acres.
Area of oranges	50,195
Area of lemons	3,015
Area of raisin grapes	20,000

It is in the great diversity of altitude and precipitation that the irrigation needs of California and the means of supplying them are found. Storage in the mountains and good engineering in the way of distribution will add enormously to the irrigable area of this wonderful State. Every system of water usage and distribution can be found therein; its practices illustrate the primitive wastefulness common to early irrigation, and the remarkable economy in the use of water which intensive farming and horticulture have already produced in the extreme southern portions of the State. Nowhere else in the world, except Madeira, portions of China, and Central Asia, has the "duty of water" been so thoroughly extended. As a consequence the price of land, the cost of water, and the security of crops have all grown in a steadily increasing ratio. Within twenty years land which the owner protested against being taxed at 75 cents per acre has been sold and is now selling at from $500 to $1,500 per acre. On the tract referred to more people are supported per acre and in greater comfort than elsewhere in the world.

The areas of fruit-producing lands on which this occurs are small in extent at present, though they are quite numerous. These areas may be greatly increased by proper systems of water storage. They may be largely added to by the restoration and conservation of the underground supplies so steadily fed by the neighboring mountain drainage.

It is difficult to make anything like a close approximation of the reclaimable area of California. With the water "in sight" certainly 12,000,000 acres will be a low estimate. Water storage on a grand scale, such as the conditions warrant, will insure the reclamation of at

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least 20,000,000 acres. A large proportion of whatever area may be reclaimed will necessarily be devoted to the raising of products possessing a high market value. Its fruits are among the best in the world. It bids fair to become the successful rival of the oldest wine-growing and wine-making lands; its nectarine, prune, grape, and orange are already found in the markets of the world. The olive, fig, lemon, date, and other semi-tropical fruits are fast becoming of great commercial importance. Nearly all these products are the direct results of irrigation, and they are all benefited by its judicious use. There were 1,537,000 fruit-trees reported in the State at the beginning of 1890.

The enormous addition to the wealth of the State and to the commercial prosperity of the whole country, which is the direct result of the high culture produced by irrigation, warrants a close attention to the united appeal of the people of California for such a survey of the public lands remaining therein and of the State's capacity for water storage as will insure to them that accurate knowledge which enterprise and investment require in the conduct of great affairs.

TAXABLE VALUES OF CALIFORNIA, 1879–1889.

A careful tabulation of the assessment valuations in some of the counties of the State illustrates very forcibly the great increase of wealth produced by the practice of irrigation. It must be borne in mind that the figures given are not over 50 per cent. of the real values.

GROUP NO. I.—*Counties enriched by irrigation.*

[Total taxable values.]

Counties.	1879.	1889.	Increase 1889.
Fresno	$6,354,596	$35,387,173	$29,032,787
Kern	6,005,460	11,831,780	5,826,320
Los Angeles	16,368,649	84,376,319	68,007,670
Merced	5,208,245	14,146,845	8,838,600
Orange	2,317,700	9,270,767	6,953,067
San Bernardino	2,576,072	23,267,955	20,690,982
San Diego	3,525,253	31,560,918	28,034,265
San Joaquin	17,377,129	38,802,606	21,425,477
Stanislaus	6,232,367	15,594,003	9,361,636
Sacramento	18,416,338	34,464,174	16,047,836
Solano	2,651,367	6,966,007	4,314,640
Tulare	5,204,777	24,343,013	19,138,236
Yolo	10,177,427	20,911,325	10,733,898
Total	102,516,281	350,922,885	248,405,414

Orange County was not formed in 1879. It was then part of Los Angeles County. The ratio estimated for increase is on one part in 1879 to four parts in 1889.

GROUP NO. II.—*Counties increasing in irrigation activity.*

[Total taxable values.]

Counties.	1879.	1889.	Increase 1889.
Butte	$10,743,426	$20,730,252	$9,986,826
Colusa	12,420,508	24,365,995	11,945,487
Lassen	1,230,764	2,527,449	1,296,685
Inyo	1,353,300	1,548,695	185,395
San Benito	3,947,728	6,332,911	2,385,183
Shasta	1,961,436	6,594,003	4,632,567
Siskiyou	2,651,367	6,966,007	4,314,640
Sutter	4,120,451	19,079,868	5,959,417
Tehama	4,199,998	11,901,255	7,701,257
Trinity	868,496	1,153,344	284,848
Yuba	4,293,630	7,046,316	2,752,686
Total	47,791,104	99,246,095	51,544,991

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GROUP NO. III.—*Foot-hill counties partially irrigated.*

[Total taxable values.]

Counties.	1879.	1889.	Increase 1889.
Amador	$2,468,642	$4,281,969	$1,813,327
Calaveras	1,871,850	4,315,461	2,443,611
El Dorado	2,312,590	3,879,887	1,567,297
Mariposa	1,295,048	1,849,641	554,593
Nevada	6,305,090	6,926,218	621,128
Placer	5,774,860	10,118,060	4,343,200
Plumas	2,115,173	2,309,441	194,268
Tuolumne	1,596,015	2,716,465	1,120,450
Total	23,739,268	36,397,142	12,657,874

The bay counties of San Francisco, Alameda, Contra Costa, Marin, San Mateo, Sonoma, and Napa present the following comparisons:

Valuation in 1879, a total of	$333,146,966
Valuation in 1889, a total of	449,992,603
Making an increase of	116,841,637

These counties are partly affected by irrigation, to the direct extent at least of one-tenth part of the valuation given.

The remaining fourteen counties, of which nine are coast counties, show the following results:

Valuation in 1879	$70,755,631
Valuation in 1889	156,039,572
Increase in ten years	85,283,941

Thus it will be seen that from 1879 to 1889 the taxable valuation increased from $577,949,250 to $1,092,598,297, an addition of $514,649,047. Of this increase nearly one-half, or $248,405,414, was made in thirteen counties, or one-fourth of the State, and is almost wholly due to irrigation. It may be fairly estimated that to the increase of irrigation in California and the rise in land values, etc., as a consequence, is due at least $350,000,000 of the total taxable increase in valuation. That will be a marketable increase of $700,000,000.

THE IRRIGATED AREAS OF CALIFORNIA.

California, though foremost in the extent and variety of its irrigation interests, enterprises, and methods, is behind several other communities within the arid region as to its statistics and data.

A full, clear, succinct statement of the irrigated areas, number of ditch systems, and the mileage, with the cost thereof, is not accessible. The best average estimate obtainable, consulting therefor the State engineer's reports, the State board of trade, evidence offered by local witnesses, and county assessors' returns to the State board of equalization, is the following:

	Ditches.	Cost per mile.	Total cost.
	Miles.		
In the San Joaquin Valley, counties of Fresno, Merced, Kern, and Tulare	800	$5,400	$4,320,000
In the counties of Los Angeles, Orange, and San Bernardino	500	6,000	3,000,000
In San Diego County	36	19,613	706,068
In the remaining part of the State, twenty-four counties, where irrigation is practiced	1,700	640	1,128,000
Counting one-third of the mining ditches in the State as available, and used for small irrigation, we have	289	3,188	921,221
Total	3,825		10,375,289

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The total valuation or cost given is below the true figures. Much of the data on which the estimates are based is taken from the assessors' returns made for the purpose of taxation. They can therefore be doubled. That will give a total cost of at least $20,000,000.

The acreage is also difficult to arrive at with certainty, but it is fairly covered as follows:

	Acres.
In the San Joaquin counties:	
In farm crops	1,000,000
In vines	13,000
In fruit trees	16,000
	1,029,000
In the southern counties:	
In farm crops	580,000
In vines	45,000
In fruit trees	85,000
	710,000
In the balance of State (irrigated):	
In farm crops	1,500,000
In vines	25,000
In fruit trees	30,000
	1,555,000

The total acreage wholly under ditch and now irrigated is fairly within the annexed totals:

	Acres.
In farm crops	3,080,000
In vines	83,000
In fruit trees	131,000
Total	3,294,000

If all the areas directly cultivated by the aid of natural sub-irrigation, etc., be added, the total area in California will certainly be not less than 3,500,000 acres. The point of interest, however, in these figures is the profitable character of such cultivation, especially in the matter of fruit-raising. Land formerly worth $1 now sells at from $500 to $2,500 per acre. The area of California is reported by the statistician of the Department of Agriculture to be divisible as follows: Tillable, 39.8 per cent.; grassland, 11.5; woodland, 35.5; unproductive (valuable, though, because largely mineral in character), 11.4. These areas compare favorably with the whole country, the per cents for the same divisions of which are as follows: 41.6; 11.5; 35.4; 11.4. In productive character California shows on grain the following:

[Bushels per acre.]

	For State.	For United States.
Corn	26.5	24.2
Wheat	13.0	12.3
Oats	28.2	27.0

THE INTRA-MOUNTAIN DIVISION.

Within the limits of the second great division of the arid region extending east and west from the one hundred and fifth to the one hundred and twentieth degree of west longitude, and north and south from the British to the Mexican boundary, irrigation works and experiments

of value will be found in progress, small in extent, perhaps, in most cases, but extensive when aggregated.

The larger portion of Colorado, New Mexico, and Wyoming are within the limits assigned. The whole of Nevada, Utah, Montana, Idaho, and Arizona, and the eastern half of Oregon and Washington Territory are also included. The region comprises 15 degrees of longitude and about 17 of latitude, and makes a total area of 1,100 by 900 miles square.

IRRIGATION AND STORAGE IN IDAHO.

The condition of Idaho, as to the hydrographic facts, the available area for reclamation, the facilities for artificial storage, and the awakened interest of the people, was found to be among the most satisfactory of the communities visited by your committee. A considerable area to the north and to the west of the Sawtooth and Bitter Root ranges is considered in the Territory as outside of the arid range. This area embraces the counties of Idaho, Latah, Nez Perces, Kootenai, and Shoshone. A portion of Lemhi is also included. Unquestionably, however, this section will also be benefited and farming pursuits rendered more secure by water storage and distribution. The remainder of the Territory embraces 32,183,040 acres, of which about 7,000,000 acres are estimated to be irrigable and arable, fertile in soil, and having accessible storage capacity and an available water supply.

The counties wherein are found the largest irrigated areas, as well as the great number of ditches with the smallest service to each, are those in which so large a number of Mormon citizens have settled. The smallness of the ditches constructed indicate the limited area cultivated by each individual or family. It is, however, always sufficient to support them in that primitive plenty which constitutes their standard of life. The primary nature of this work can be seen when an estimate is made of the cost per acre.

In Bear Lake County the total cost for the 21,500 acres irrigated is given at $73,500, or a fraction over $3.60 per acre. The ditches of the northern portion of Bingham County cost $435,000, or a cost per acre of $1.775. Small as this price appears to be, it is necessarily costly, because wasteful. As the water in sight is absorbed, storage becomes a necessity, and the result is the abandonment finally of the small ditches, and the reconstruction of service works on a larger, and of necessity, costlier (at the outset) scale. Taking the medium between the two rates given, and the cost per acre of irrigation in Idaho may be set at $2.66 per acre, or a total for 715,500 acres of $1,187,000.

The extensive river system of Idaho renders the reclamation of its arid lands a very interesting problem. The need of storage is insisted upon. The importance of the river system of Idaho can hardly be exaggerated from the stand-point of reclamation; the number and volume of minor mountain streams must also be considered. Some slight idea of the water supply may be obtained by the presentation of a few of the estimates made in the testimony:

	Cubic feet per second.
Flow of Snake River (at Eagle Rock)	5,000
Flow of Salmon River (in Cassia County)	1,820
Flow of Boisé River	6,000
Flow of Payette River	1,000
Flow of Weiser River	180
Flow of Big Wood River	154
Flow of Raft River	745

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These estimates are necessarily partial. They embrace with tolerable accuracy the surface drainage flow above the point of measurement, but they take no account, of course, of the addition to the river volume accruing from the remainder of its other local areas of precipitation and drainage. The average annual rain-fall is about 13 inches. The snow-fall is given at an average of 6 cubic feet of packed snow on the ranges. This will give at least, in melting, about 2 cubic feet of water. The capacity, then, of Idaho for storage by main reservoirs at high altitude and at or near the sources of its great streams becomes one of the problems that may be approximately measured and calculated upon.

The Hon. E. A. Stevenson, of Boisé City, Idaho, presented to the Senate Committee on Irrigation, at their Idaho session, valuable testimony as to the value, character, and results of irrigation. A brief summary of its chief points is given. Mr. Stevenson said:

This town was settled in 1863, but very little agriculture was attempted until 1864 or 1865. When I first saw this town this portion around here was as poor a sage-brush place as you would find in Idaho—a miserable sandy place that nobody imagined would grow anything. It was that way all along this valley. There was a little strip along the river where some grass grew and where there were some willows and trees. The first men who came here settled on that low bench-land, and they have the poorest farms in the country. Those who went back on the sage-brush plains have land that is worth five times as much as the other. And so it is in Washington Territory, at Walla Walla. All those men who went on the Touchet, and all those streams, have poor farms; those who went on the high lands have good farms. But this land without irrigation would produce nothing. It might, if it should rain in the fall, produce a crop of rye, but there is no dependence to be placed on it. But rye will grow almost any place. I have had some experience with irrigation. My partner and I dug a ditch 22 miles long down on the Payette River. We took some water on to some desert land that we have there, and in five years we have raised orchards with lots of fruit. I have cut the grass there twice this year already, and there is a regular forest where there was not a tree in sight in the country. In a short time, five years, these trees were 5 inches through.

The trees are apple, pear, plumb, peach, apricot, prune, and poplar trees; box-elder, walnut, locust, and all the different varieties. I took small trees in a two-horse wagon down there. I told some persons that five years ago I took in a two-horse wagon all the trees that are growing there to-day, and they were thunderstruck. A man can not imagine that it could be done. But it is marvelous how the trees grow there. I do not think you can raise cereals where you have to irrigate and compete with a country that does not. But in all other kinds of crops, vegetables, I think we can raise all kinds of fruits and vegetables. An irrigated country requires more population. The holdings should be small. A small farm will support a good family if it is well irrigated. The system of irrigation is crude. They do not understand it. Some give too much water and some too little. Some farmers might live on 60 acres. But I think it would be better for the country to cut it up into 80 acres; 40 acres would make a good home if well cultivated. Now, on the Payette River the supply of water is abundant without storage, and will water all the land on it. There is a large amount of water there now. But on the Boisé River it would need storage. There is plenty of water here with proper storage facilities to cover the whole country. I am speaking of Lewiston. Around the city of Lewiston they could not raise fruit in the garden without irrigation. They irrigate there altogether.

L. F. Cartee, formerly surveyor-general of Idaho, and a practical horticulturist by irrigation, gave to the Senate committee the results of his own work and observations. He said in substance that—

Idaho sage-brush land is capable of producing anything that can be raised in this latitude anywhere, not only all the varieties of fruits, but all the cereals. I have forty different varieties of grapes on my place, and they nearly all ripen except the Catawba. That does not ripen because of the shortness of the season. Our grape is of fair quality; better than any of the eastern grapes that we have. A fair crop of wheat on our irrigated land is from 25 to 50 bushels; of oats it is from 30 to 60 bushels; occasionally 70 to 80 bushels, but that is exceptional; barley is the same as wheat—25 to 50 bushels. Timothy hay averages about 2 tons to the acre, and alfalfa returns 6 tons. Red clover will give the same. Potatoes return 600 bushels to the acre. This is the finest apple country in the world. All do well here; you

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can hardly find an exception. They grow to a large size and the trees are heavily loaded. Peaches do well, but plumbs and prunes do remarkably well, better than in any country in which I have been. Pears are very good also.

At the same session fruit, still on the branches, was exhibited. One limb, 2 feet in length, had on it 29 peaches, one of which taken off at random measured 8½ inches one way and 8¾ another. On a branch 14 inches in length 27 large plums were counted. A pear was measured and found to be 11½ and 10½ inches in circumference. These are reported as taken without selection from a large variety.

MONTANA AND WATER STORAGE.

Montana, with its 93,349,200 acres, is not only one of the three largest States—the others being Texas and California—but it is without question the best watered one west of the one hundredth meridian. It is heavily timbered also; its pastoral area is great, and, according to the estimate of Statistician Dodge, its tillable area is not less than 32.9 per cent., or close to one-third of the total.

The river courses that drain the central basin of our land find their beginnings in the sources of the Upper Missouri, with its great tributaries of the Yellowstone, Gallatin, Jefferson, Madison, and a score more important streams that all head in and receive their primal supply from the precipitation and drainage of the upper Rocky Mountain ranges. The valleys are usually narrow and long. The Yellowstone is an example, presenting as it does a tillable valley or bottom area of about 400 miles in length, with an average width of not to exceed 3 miles; in all about 780,000 acres. Such streams, large or small, usually present similar features of deep, narrow valleys, in which the waters appear to be slowly but steadily eroding deeper channels; then comes a precipitous rise to the mesa or bench land of from 25 to 100 or more feet in height. The mesas will widen their sections of the several hydrographic basins to from 8 to 12 miles in width. The secondary table-land or plateau is then reached by steep ascent, making them often as high as from 600 to 1,000 feet above the bottom-land. These mesas and table-lands are everywhere covered with succulent grasses. They are everywhere found to be fertile in capacity, if water can be obtained. It is these facts that make Montana a typical region in which to conserve the waters by storage and subsequent distribution for purposes of irrigation.

The Yellowstone Basin, from a reclaimable area in the lower valley of 780,000 acres, will rise rapidly under a system of scientific engineering to an agricultural capacity of from 3,000,000 to 8,000,000 acres. When storage shall be so advanced and distribution so systematized that the secondary table-lands may be reached and quickened, the largest area named will be readily compassed. Nor does this statement close the possibilities of the drainage or hydrographic basin of the Yellowstone. The tributary valleys found there, many of which are quite large, will furnish an additional 4,000,000 acres to the area of reclamation. This is illustrated in a report made by the authorities of Custer County, within which a large portion of the main Yellowstone Valley is located. That report gives the valley land area at 384,000 acres, and for fifteen other tributary valleys within the county, including the Tongue, Powder, Rosebud, and Otter, it gives their valley areas at 501,600 more acres.

The volume of water to be supplied from the Yellowstone alone is estimated by the same authority for use in the areas under consideration

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at 906,000 miner's inches per second, flowing under a 6-foot pressure. The testimony warrants the statement that the Yellowstone alone can furnish for irrigation purposes some 4,000,000 miner's inches. With proper storage this may be greatly increased, perhaps doubled. The wisdom of the policy which reserved as a national park the wonderland in which the Yellowstone finds its ample sources may yet be proven in ways heretofore unexpected. The storage of its quickening waters will be greatly simplified by the inability of speculative occupiers of the public lands to exploit those valuable sources. Hundreds of millions of dollars may yet be added to the nation's wealth as a consequence of the National Park reservation.

The Yellowstone is taken as an illustration of the fact that the earlier or primal attempts at irrigation are decidedly wasteful and often provocative of contention, disorder, and litigation. The valley or bottom lands, though the most readily reclaimable by simple local ditches, are seldom, perhaps never, the most desirable for farming purposes. It is always the warm red loams and soils of the mesa and table lands that will furnish the largest crops as a return for industry. It is on these benches, open to the sun, made up of the most fertilizing components and readily washed by water of alkali salts, that the Western farmer will in the not distant future, wherever water is accessible, make from his occupation a return almost as certain and controllable as does to-day the carder of wool and the weaver of cloth.

No cultivation of the soil is possible in Montana without irrigation. Without ample storage of water the reclaimable area will be a limited one; with ample storage it will rise, according to different witnesses and reports, from 20,000,000 to 30,000,000 acres. With irrigation an acre of ground in Montana will exceed in productive value from 3 to 5 acres in the humid or rain-fall States. The average production per acre is estimated as follows: Wheat, 35 bushels; oats, 50; barley, 45; corn, 28; alfalfa, from 4 to 6 tons. The percentage of productive capacity for Montana per acre may be stated as follows:

	Products.		
	Wheat.	Oats.	Corn.
Average number of bushels per acre in Montana	17.8	34.2	26.2
Average for the United States	12.3	22.3	27.0
Average per acre for whole arid region	18.9	24.9	28.9

The number of farms is 1,519, the percentage of agriculturists 20, and the average value of land is a little less than $8 per acre. During the past ten fiscal years 6,904,461 acres of public lands have been disposed of in Montana, of which total 5,304,778 acres have been settled upon, sold, or patented during the past four fiscal years ending June 30, 1889.

The statistics presented as to irrigation ditches were very imperfect. It appears that there were in 1869 of mining ditches 287½ miles, constructed at a cost of $806,500. The present extent, including these, as many have been used for irrigation purposes also, is now estimated at 1,000 miles. There are now partially or wholly completed the following larger or district systems, constructed for rental investment by corporations:

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Ditches.	Miles.	Acres to be served.	Estimated cost.
Benton Lake	35	50,000	$175,000
Clarke Fork	38	100,000	140,000
Chestnut Valley	10	25,000	7,000
Dearborn	45	51,000	150,000
Florence	50	10,000	200,000
Gallatin	25	50,000	75,000
Sun River	75	300,000	500,000
Teton	40	35,000	80,000
Total	318	611,000	1,327,000

Under a proper system of irrigation, storage, and distribution land now worth but little beyond the Government price of $1.25 will rise rapidly to $20 and $30 per acre.

EASTERN WASHINGTON AND OREGON.

The States of Washington and Oregon present interesting irrigation and reclamation features. In an area well within the arid region, the extensive mountain lakes found in northwestern Montana, northeastern Washington, and northern Idaho subdue to a considerable degree the regional aridity. The extreme eastern quarter or third of Washington from north to south may properly be classified as subhumid, while the central portion clear to the eastern foot-hills of the Cascades approaches more nearly to a general arid character. Washington, from 117° to 121° of west longitude, or four degrees, will be found a section in which the storage and distribution of water, while not at all times and places therein an absolute necessity, will always need such facilities and find them to greatly enhance its land values and industrial progress. There is a great area almost wholly unreclaimed, formed by the mesa or table-land of the Columbia River Valley and its great tributaries. The Columbia River Plains to the northwest of the North Pacific Railroad will probably require for their arable use an extended series of hydrographic works. That they can be so reclaimed is testified to from many sources. One estimate is made of 8,000,000 acres, another of 12,000,000. Irrigation by private parties or companies has been successfully tried in a number of valleys, viz: The Klamath River Valley, both in Oregon and northern California; the Boisé River Valley, Idaho; the Snake River Valley, Washington and Idaho; the Colville River Valley, Washington, and in the Rogue River Valley, Oregon. The rivers of this region are large and furnish enough water to supply systems of irrigation ditches, which could be supplemented by storage reservoirs if necessary, or when the demands increase. The region around Walla Walla is rich and productive. The Great Plains of the Columbia, although not so well known, is a promising country. Both regions are poorly supplied with water during the summer months, at least. The Snake River above Lewiston has falls and rapids, and may afford an opportunity of running irrigation ditches to the lower lands below.

All of the great bodies of water named present the usual characteristics of the arid region—deeply eroded channels, low, narrow valleys, abruptly rising bench lands opening widely one or the other side of the river, but seldom on both sides, and then again rising into grass-clad table or plateau lands. At North Yakima and Ellensburgh can be seen the results of irrigation on an extensive scale. The Moxie ranch

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at the first-named place illustrates in its 7,000 acres, irrigated from the Yakima River at an average cost of $8 per acre, what may be accomplished by private enterprise backed by capital, while at Ellensburgh the Kittitas Valley offers a splendid evidence of neighborhood energy and self-dependence. The Yakima Valley people estimate 200,000 acres of bottom lands for reclamation and at least a million more in available bench lands. The rain-fall of the region is also sufficient to secure a large area of "subirrigated" land. That is to say, where the soil retains below the surface much of the precipitation and drainage that percolates into it.

The production per acre is given of wheat at from 35 to 50 bushels; of oats at 60; of barley from 50 to 80; alfalfa yields from 6 to 10 tons per year, while potatoes will return more than 500 bushels to the acre. One half of eastern Washington needs storage and full facilities of irrigation. The cost will range from $3 to $5 per acre, and there may probably be found an abundance of water for storage. The cost of water in irrigation is about $1.50 per acre.

The Kittitas Valley without water is but a sage-brush desert; irrigated, it becomes a garden spot and produces bountifully of cereals, fruits, and vegetables. About 22,000 acres of land are now under cultivation. All small fruits, as well as apples, plums, pears, etc., grow to perfection; peaches do not do so well, except in localities bordering on the Columbia and Wenatchee Rivers. Vegetables of all kinds and of the finest quality are grown upon every farm.

In these valleys of the Yakima, including the Nachez Valley and the Yakima Valley proper and the valleys tributary to the Yakima, the irrigating season commences in the months of May and June principally. Very little land west of the Columbia River, in what is known as the Columbia River basin, is susceptible of cultivation without irrigation except, perhaps, for hay. Many people produce hay along the river by subirrigation or percolation. The finest store-house of water is the snow-clad mountains. Fort Adams is an everlasting store-house. The waters of the Yakima and the Tietan flow in there in ordinary seasons, and without any storage whatever those would irrigate an extremely large area of country.

In the extreme southeastern section, around Pasco, Walla Walla, and east to Lewiston, in Idaho, there is a region famous for fine fruits and vegetables, in which the use of irrigation adds enormously to the value of the land. It is a region also of accessible and not very deep artesian water, and it illustrates, too, the rapid increase of precipitation at rising altitudes. The average annual rain-fall at Walla Walla is given for five years past at 18 inches; at Dayton, 30 miles distant, it reaches 27 inches. That is a rise of less than 700 feet. To be accurate, the height above sea-level at Walla Walla is stated at 1,000 feet; at Dayton, at 1,675 feet. The advantages offered by this region are testified to by some State census figures, which show that the proportion of settlement in Washington during two years past has been in favor of the section east of the Cascade range. In 1887 there were in Washington 144,000 persons; in 1889 the estimate made from county returns showed 240,000. In the western counties the total population was 142,132; in the eastern counties it was 97,868; an excess for the west of 44,264. The total increase for two years is given as 95,991. Of this, the region between 117 degrees and 121 degrees, or East Washington, got 41,298, while that west of the Cascades got 35,693.

Oregon is estimated to have received 100,000 new settlers during the same two years or less, of whom 60,000 at least have remained east of

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the one hundred and twenty-first degree of west longitude. During the past twelve fiscal years ending June 30, 1889, these two States show a public land settlement as follows: Washington, 13,335,937.03, and Oregon, 6,149,540.05 acres, or a total of 19,485,477.08 acres. The amount paid into the land offices during the fiscal year of 1888–'89 was, for Oregon, $35,332; and for Washington, $39,538, or $74,870; or a total of one-eighth of the receipts for the whole arid region. Washington has made natural waters public property by constitutional provision.

The arid and subarid sections of Oregon are somewhat more extensive than the similar ones in Washington. Their great feature is the drainage basin of the Columbia River, in the north, with its extensive tributaries—the Deschutes, John Day, White, and Powder Rivers—and on the east the lower valley of the Snake River, which forms the western boundary line of Idaho for two-thirds of its length. Below that is the Oregon portion of the Owyhee River and its branches. In the southwest, the Klamath River and lakes form an extended drainage basin, in which large irrigation operations have already commenced.

IMPORTANCE OF IRRIGATION IN UTAH.

Utah presents an extensive system well under way. A large area has been reclaimed. The value of the work accomplished is seen not only in the valleys near to Salt Lake City, but in all the Mormon settlements within the Territory. The influence of the Mormon polity in directing industrial activity has often been commented upon. In no one thing is it more apparent than in this great work of the conservation and distribution of the water supply. It exhibits several noteworthy features. They are:

(*a*) The treatment of natural water supplies, under legislation, as public property, to be used for the common benefit.

(*b*) The construction of all distributive agencies (artificial) at the cost necessarily of those to be benefited.

(*c*) The incorporation of the expected beneficiaries by neighborhood companies, under general law, and the assessing of costs co-operatively, by means of share purchasing and holding, according to the number of acres to be served by the water so utilized.

(*d*) The distribution of water under stated regulations, which have the effect of law, under the supervision of an officer specially chosen for the purpose.

(*e*) The payment for this authorized use by means of stated rates, levied upon the volume of water used.

The Mormon irrigation laws provide for the proclamation as a water district of any piece of territory which can be commanded by an irrigating ditch, the nomination of water masters, penalties against wasting water, the giving of permission to carry the ditch through any private property upon a fair valuation for the land used, authority to tax for maintenance of channels, and to appoint taxation trustees, whose powers are made very broad with respect to determining what shall be described as land benefited by the construction of the irrigating channels. The law also gives protection to primary water rights, which means that any person who has drawn water from a water-course by means of an irrigating work previous to the proclamation of any locality as a water district, has his right protected as a primary claim up to the quantity of water he was in the actual use of at the date of proclamation. Having covered these points the law has made the way open for the action of private enterprise, which in all cases undertakes the construction. The next step is the formation of a joint-stock com-

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pany, which may be formed of not less than three individuals, and not more than seven, and further provides that such corporation work shall be exempted from general tax for county and State purposes, to which all other kinds of property are subject. The farmers and others interested then meet in public and arrange the formation of the company and the distribution of shares, and then vote as to whether the tax for maintenance and management purposes, after the main ditch has been completed, shall be upon all the land within the water district or upon "the land to be benefited." They can also confer arbitrary powers upon the assessing trustees, as a difficulty had been found to occur with parties who refused to contribute to the maintenance tax on the plea that they are not taking water, although, owing to favorable positions in relation to either the main or subsidiary ditches, their lands are being effectually irrigated by means of seepage. The shares are always $10 each, and each share represents an acre of land with a perpetual water right to that acre, subject only to the maintenance tax. The company being formed, the farmers, or intending farmers in most cases—for many of the tillers have just arrived as immigrants—of the water districts take up all the shares they can. This is usually a very small percentage of the whole, as they are poor, and their shares are mainly paid for by work in the ditch. After the farmers have taken their shares, the wealthy citizens take the balance amongst themselves, and on goes the making of the ditch, the intending farmers working on their farms at the rate of $20 a month, and the non-working shareholders putting on labor by contract, which amounts to an average of 10 cents per cubic yard, the heavier work in the cañon being by special agreement, according to the difficulties of the work. When the work is completed the farmers have as many water rights as they have taken out shares, and they who have furnished most of the capital then begin to make their profit.

Small farmers generally secure a water right for each acre, but others who hold, say, from 40 to 80 acres, sometimes only take water right sufficient for half their area, working one-half as a tillage-farm and the other as a grazing-block, alternately. A water right means the privilege of taking as much water as the land requires during the irrigating season, and the maintenance tax varies from 10 cents to 16 cents per acre per annum, according to "easiness" or otherwise of the channels. Subsidiary ditches, called laterals, are made by the farmers at their own cost, from side heads fitted with sluices, through which the water-master lets out as much water as may be required during any particular day. Thus there may be ten farmers along a certain lateral holding from 5 to 40 acres of land each, and they may have water rights to cover the whole or any part of their holdings. The water-master knows how many water rights are along each lateral, and every morning he looks at his notice boxes, which are attached to the sluice-heads at the place where the laterals leave the main channel. The farmers generally arrange to irrigate day about, each at the proper time posting up the notice, "I intend to irrigate to-day," and as the water-master knows how many acres are possessed by the person signing, and how many water rights, he is able to make his arrangements accordingly. His water-gauge, which is simply a wooden slat in the lateral sluice-head, graduated so as to let a certain number of cubic feet run through in a given time, is then lifted to the necessary mark, and the water laid on until the irrigation is completed. The gauge is arranged so as to let a cubic foot per second flow through for each hundred acres of land. Thus: If A's notice represents five water rights, B's fifteen, and C's

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thirty, the water-master knows that fifty water rights want water, and he sets the gauge to run at the rate of half a cubic foot per second. This is not for the purpose of measuring the water, but only as a gauge to arrange the flow to suit the irrigation requirements of the several farmers situated along the lateral.

The time occupied in flooding a certain area differs according to the "lay" and quality of the soil. The water-master soon learns how much time each irrigator usually occupies, and his knowledge on that point, together with the law against wasting water, which is strict, operates to prevent the flow of water longer than is absolutely required. The water-master notes in his book the time of letting the water on, together with the number of water rights that are drawing, and it is his business to visit the irrigators about the proper time, and see about shutting off.

THE WATER LAWS AND PRACTICES.

The legal aspects of Utah irrigation are thus as remarkable as the economic ones. Indeed, they are related to each other, and the laws could hardly have been framed by any other community. But their value extends beyond the locality for which they were framed. Prior appropriation is the foundation, but so modified by the uses of water in the interests of the community as to make of that principle something quite broader and more equitable than has elsewhere been the case. In other words, priority has not been abused in Utah. The county selectmen are *ex officio* water commissioners, with the power to record all appropriation and regulate the distribution of natural water. Appropriators can be persons or corporations. Rights are divided into primary and secondary, the latter being a feature of water legislation peculiar to Utah. A primary right vests under the following circumstances:

(1) Whenever any person or persons shall have taken, diverted, and used any of the unappropriated water of any natural stream, watercourse, lake, or spring, or other natural source of supply.

(2) Whenever any person or persons shall have had the open, peaceable, uninterrupted, and continuous use of water for a period of seven years.

A secondary right to the use of water for any of said purposes is hereby recognized and acknowledged to have vested and accrued (subject to the perfect and complete use of all preliminary rights) to the extent of and reasonable necessity for such use thereof, under any of the following circumstances:

(1) Whenever the whole of the waters of any natural stream, watercourse, lake, spring, or other natural source of supply has been taken, diverted, and used by prior appropriators for a part, or parts, of each year only; and other persons have subsequently appropriated any part, or the whole, of such water during any other part of such year, such person shall be deemed to have acquired a secondary right.

(2) Whenever, at the time of an unusual increase of water exceeding seven years' average flow of such water, at the same season of each year, all the water of such average flow then being used by prior appropriators, and other persons appropriate and use such increase of water, such persons shall be deemed to have acquired a secondary right.

The measurement of water is definitely provided for by "fractional parts of the whole source of supply" or time limit, or by a specific ratio of measurement, or this combined with time limit. Provisions are made for repairs, damages, continuous use and service, against waste, and for the return of unused water to its proper channel; also for pro rata

distribution when supply fails in volume, as to equal right of way, and for the organization of local copartnerships or corporate direction. Another act provides for irrigation districts and their lawful control, with trustees, and the powers as to water and its control and use, of any subcivic or county body.

There are two or three systems of distribution. First are the incorporators on the streams, controling it themselves—they agree how it shall be manipulated; second, the county courts that matured and organized irrigating companies; and, third, private corporations, taking out charters the same as any other corporation would, as, for instance, a person or a company of men settle upon a stream and appropriate the water in it. In early times they had sufficient to irrigate what land they would break up. These may be termed the primary owners of the water. Afterward others, finding a surplus of water in the stream, appropriated still further water, and so on until all the water of that stream is taken out. In establishing some streams there is then what is known as the first, second, and third right. The third right, when there is a scarcity of water, shuts off the entire stream, and the second and first rights take the entire stream. The owners of each of those ditches meet and appoint what is called a "water-divider" or "water-master," who has control of the ditch for that year, and whose duty it is to divide the water of the streams into ditches. For instance, if there were four streams drawing water, the farmers would appoint a divider to turn the water of those streams into the ditches, and the water-master take the water as it flows into the ditch and give it to the owners as their rights appear. The private companies so called are incorporations where certificates of stock are issued under the general laws of the Territory. They elect their board of trustees and manage the affairs of the company. Those trustees appoint a water-master, who takes the number of shares each owner of has and divides to each his proportion of the water that comes through a certain ditch from the stream. Those streams are mostly artificial streams, having been taken out from some large body of water. That system prevails largely on the west side of Salt Lake. The stockholders have the land, but the water right can be transferred without transferring the land. It is a water right independently of the land.

Yet the water must be "in place," and in order to use it, the land served by that way must be obtained. As a practical fact a water right, that is, one share in a corporation, represents only the service of water for 1 acre of land. And it is a particular acre in a special place. Therefore the one share of water can only serve that 1 acre of land, or rather any 1 acre within the area to be irrigated by that particular body of water in the service or duty of which one share has been obtained.

In the distribution of water the horary or time system has been adopted. The irrigation survey engineer states that the following forms indicate the method of distribution by "the hour," as is the case in Spain:

No. —.

TIMPANOGOS IRRIGATION TIME TICKET.

Mr. ——————. On —— every alternate week, from — o'clock — m., and until — o'clock — m., ——— amount of stream, all of the water in said ditch.

————,
Water-master.

No. —.

TIMPANOGOS IRRIGATION TIME TICKET.

Mr. ——— ———: You are entitled to the use of water from the Timpanogos Ditch on ——— every alternate week, from —— o'clock — m., and until —— o'clock — m., ———; amount of stream, all of the water in said ditch; when you are required to discontinue to use and turn it off.

——— ———, *Water-master.*
Per ——— ———, *Deputy.*

PROVO CITY, UTAH, ——— ——, 18—.

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The annexed blank receipt shows the manner of meeting the water-tax levy on proof of labor performed.

No. ——

Am't of labor, ——
Am't of cash, $——
——
Total, $——
Issued to and received by —— ——.
Date, ——, 188—.

No. ——

Received of —— —— —— days' labor, $——
Cash ..... ——
——
Total ..... ——
In full for his water-tax, for the year ending March 1, 188—.
—— ——, *Water-master.*
Provo City, Utah, —— ——, 188—.

THE PUBLIC DOMAIN IN UTAH.

Within the Territory of Utah will be found several varieties of climate, ranging almost from semi-temperate in the north to semi-tropical in the south. The production of corn is limited; that of wheat and oats is large. Wheat brings 80 cents a bushel and runs from 25 to 30 bushels per acre. Oats bring from $1.16 to $1.60 per hundred pounds. Potatoes will give 300 bushels to the acre. A farm of 40 acres is quite sufficient for profitable cultivation. In the southern portion of the Territory the raising of fruit is claimed to be a success. Artesian water is found in several counties and over large areas.

The disposition of the public land domain in Utah for the past twelve fiscal years outside of mineral lands has been 2,681,605.96 acres. The percentage of Utah in farms is 1.92 of the whole. The entire arid region has but 2.85 per cent. Of tillable land Utah has (whether or not there be water for the same) 45.5 per cent. of its whole area. Of grass it has 18 per cent; of wood-land but 3 per cent. The unproductive area is set down at 11.4 per cent. of the whole. The question of reclamation in Utah then is, as elsewhere, one of mountain precipitation, of subterranean supply, and of artificial water storage and subsequent distribution. The rain-fall ranges from 7 to 17 inches per annum. The snow-fall is from 5 to 25 feet. In the mountains the precipitation is as 3 to 1 in quantity over the lower lands. The average yield of corn per acre is given at 22.5, of wheat at 17.8, and of oats at 26.3 bushels—an average which is close to the normal mean for the whole country. With these figures, it is evident that Utah holds larger promises than its past has achieved.

The most expensive thing in connection with an irrigating work in Utah, as elsewhere, is the main head, where the water is taken from the stream. Sometimes the channel is taken sufficiently far up the cañon to tap the stream without a dam, but in other cases it is found the lesser of two expensive works to dam the stream at a lower point rather than undertake the heavy quarrying or tunneling required higher up. The dams are of various kinds, according to circumstances, but that known to engineers as "the mud-sill" is mostly built over broad, shallow streams, and "the crib" used for deeper and narrower torrents up the cañons.

The usual plan of irrigation is to go well up the cañons and start a channel 20 feet wide by 4 feet deep, and carry this along the side of the cañon, and then around the side of the main range so as to command as large an area of level land as possible. The ditching, except in the rocky portions at the head of the cañon channel, is done by plow and scoop, one of the lightest of the latter implements, worked by a pair of mules, being invariably used. There are two 30-mile-long main ditches led along each side of the Jordan, and one 35 miles long is con-

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ducted from a mountain cañon in the direction of Provo, along the foot of the range towards Salt Lake City, thus providing water for a considerable area of country under the ditch.

Each acre of land brought within the influence of the canal is increased in value, and the $10-shares go up in the market. The water enables the working farmer to pay his passage-money back to the Mormon Church, together with the tithe of all he raises, and further the expenses of his maintenance advanced to him during the construction of the ditches; and yet, after paying all these charges, in addition to, say, 10 cents an acre for maintenance of the ditches, he makes money. Each share in the Provo ditch, for instance, costs $10. That represents an acre of land, with a perpetual water right. Without the water right the land was absolutely valueless. It is now quoted at from $25 to $60 per acre, according to situation.

CONDITIONS AND POSSIBILITIES.

In 1875 there were in the twenty organized counties 2,095¼ miles of principal canals, costing $1,918,174, and 4,888¾ miles of tributary canals, costing $503,320. This was a total construction of 6,984 miles of canals and ditches, at a cost of $2,421,494. The total cultivated area within the district "under water" was 302,766 acres, of which 106,184 acres did not require the application of water at all. Mr. Caine, Delegate in Congress from Utah, under date of December, 1884, estimated that there were in the four most prosperous counties of that Territory irrigation (main) canals, as follows:

Counties.	Main canals.	Estimated cost.
	Miles.	
Weber	165	$300,000
Utah	150	250,000
Cache	175	550,000
Salt Lake	190	1,250,000
Total estimate	680	2,350,000

CLIMATOLOGY OF UTAH.

Prof. Marcus C. Jones, of the Deseret University, at the request of Governor Thomas, presented, in 1889, to the Senate Committee on Irrigation, among other papers, the following review of the Territory:

The annual rain-fall of this Territory will not exceed 8 inches per annum, and were it not for the lofty mountains storing up the water in snow the Territory could not be inhabited. Therefore the settlements are to be found along the streams which are fed by the snow, and they are located chiefly at the bases of the mountains, though running out into the valleys as far as there is water.

The Wasatch, rising over a mile above the valleys, run from north to south through the Territory, a little west of the middle, till they reach Iron County, where they turn to the southwest and fade away in Nevada. Their average height will not fall far below 10,000 feet above the sea.

Nearly east of Salt Lake City the Uintahs, still loftier than the Wasatch, abut on them and run eastward till they pass out of the Territory. These are so close to the northern edge of Utah that we get little benefit from them, while to the south of them is an Indian reservation. Nearly due east of Utah Lake, and about 40 miles from the Wasatch, the Coal range starts from the Uintahs and runs southward parallel with the Wasatch for 160 miles, when it joins them at Panguitch Lake. These three ranges form the water-shed of Utah, the Coal range and the Uintahs forming the rim of the Great Basin, while the Wasatch performs a similar part below Panguitch.

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The Wasatch and Uintahs are narrow, lofty, and rugged, while the Coal range is younger, lower, and broad. The Coal and Wasatch inclose between them some of the most fertile valleys of Utah. The Wasatch reach their culmination near Salt Lake City, and, aided by Great Salt Lake, give the greatest water supply in the Territory. The streams from this source irrigate the bulk of the cultivated area of Utah.

For ease in comprehension Utah may be divided into three divisions, the moist counties, whose rain-fall exceeds 12 inches per annum, the dry counties, with a rain-fall of 6 to 12 inches, and the hot counties, with a slight rain-fall and great heat.

The moist counties are Cache, Box Elder, Rich, Morgan, Weber, Davis, Summit, Salt Lake, Utah, Wasatch, Uintah, San Pete, Sevier, and parts of Emery, Garfield, Pi Ute, and San Juan.

The dry counties are Tooele, Juab, Millard, Beaver, Iron, and parts of others.

The hot counties are Washington, Kane, and parts of San Juan, Pi Ute, and Garfield.

THE MOIST COUNTRIES.

Cache County is situated in the middle of the northern end of the Territory, at an elevation of 4,533 to 5,000 feet above the sea. All the arable land is in Cache Valley, which lies between two ranges of mountains, the Wasatch forming the eastern boundary. The water supply is 420.13 cubic feet per second, and comes from eight streams and rivers. The whole supply will be in use next year. The area of the county is 633,600 acres, of which 43,154 were cultivated this year. One thousand seven hundred and ten acres were dry-farmed, and 14,385 acres of crops were lost by lack of water. There are forty canals reported, aggregating 110.5 miles. The irrigating season is 122 days long, and land is irrigated 35 hours per year. The duty of water is less than a cubic foot per second to 100 acres. The average depth of snow in the mountains is 3 feet. The committee report water storage as the only means of increasing the cultivated area, since there are more than 420.13 cubic feet per second running to waste for 243 days, enough to irrigate from 50,000 to 75,000 acres. Many good reservoir sites are mentioned, but details are not given. It is probable that artesian wells can be obtained in some parts of this valley.

Box Elder County.—This lies in the northwest corner of the Territory. The eastern part is very fertile and well supplied with water, but the western and greater part belongs to the dry counties. The area is 2,767,360 acres, of which 53,280 acres are cultivated, and of these latter 19,190 acres are cultivated but not irrigated. The elevation of the fertile parts is 4,215 to 5,000 feet above the sea. There are 12 canals reported, length 76 miles. A branch of the Great Bear River canal is to irrigate a large area in this county. Large quantities of fruit are raised here, and still greater amounts of small grain and hay. The extensive valley of the Bear has been for half a century the recruiting place for overland travelers by team. Artesian wells are very numerous and add greatly to the productive area. Water storage is the main question here. Five reservoir sites are reported in detail, and several others in general. Bear Lake is the natural reservoir for this and Cache County, and will store all the water that will ever flow into it.

Rich County.—This lies at an elevation of 6,000 to 7,000 feet above the sea, in the northeast corner of the Territory, at the eastern base of the mountains. It is high and cold, raising only small grain, hay, etc. It lies all in one valley; is watered chiefly by the Bear River and some streams that flow into the lake. This land takes little water to mature crops, and much produce is raised without irrigation. The soil is sandy. The area of the county is 497,280 acres. There is no report from this county.

Weber County.—This lies south of Cache, extending from Great Salt Lake through the Wasatch to the headwaters of Ogden River. The best portion lies in Salt Lake Valley at an elevation of 4,315 feet, while Ogden Valley, lying along that river, lies east of the Wasatch and is more elevated. The water supply of the county comes from 17 streams and rivers, flowing 323.66 cubic feet per second. There are 117,600 acres under cultivation, of which 29,400 acres are fully irrigated, while the rest is partially irrigated or dry-farmed. The soil is sandy, with clay close to the lake. Five thousand one hundred and seventy-two acres are irrigated from artesian wells. The duty of water is one cubic foot per second for 80 acres, or thereabouts. There are 25 canals, length not given. The irrigating season is 122 to 152 days long. This county is one of the most productive that we have, raising all kinds of fruit and produce that is raised in the Great Basin. The only solution of the water question here is storage. There are over 323.66 cubic feet per second going to waste for 213 days, enough to irrigate 30,000 to 40,000 acres. One reservoir site is reported, of small dimensions, while others are reported from Huntsville and Wheeler's Creek, and there are numerous sites at the head of the Weber.

Davis County.—This county lies wholly west of the Wasatch, being south of Weber and north of Salt Lake Counties and between them and the lake. There is very little waste land in this smallest county in the Territory, whose arable land lies wholly

in Salt Lake Valley. This county is well watered close to the mountains by numerous small streams, and lower down by multitudes of artesian wells. Many acres are not irrigated. This county is full of orchards, gardens, and fields, while roots, small grain, and hay are raised in abundance. The elevation is 4,215 to 4,500 feet above the sea. The area is 160,000 acres. The soil is sandy but with clay near the lake. There is no report from this county.

Morgan County.—This lies directly east of Davis, on the east side of the Wasatch, and occupying Weber Valley as far as Croyden. This is elevated nearly 6,000 feet above the sea, and is only adapted to small grain, root crops, and hay. The water supply is fair and the opportunities for storage good. The area is 675,840 acres, of which about 10,000 acres are cultivated. The soil is chiefly sandy.

Summit County.—This county lies almost wholly in the upper valley of the Weber, and includes Parley's Park. It occupies the angle between the Wasatch and the Uintahs, and lies north of the latter. Its ultivated land is elevated 6,000 to 8,500 feet above the sea. It is cold and best adapted to small grain and hay. Much produce is raised without irrigation, and only a small amount of water is required per acre to mature crops. The valley of Weber is a succession of green fields for many miles, while on Chalk Creek and other tributaries are scattered many farms. The area of the county is 2,419,200 acres, of which 7,500 are under cultivation. This county also reports storage of water as the only means of increasing its cultivated area. Deep artesian wells might be successful here. The soil is sandy.

Salt Lake County.—This county lies between the south end of the lake and the Wasatch Mountains, occupying all of the southern end of Salt Lake Valley and lying between the Oquirrh and Wasatch Mountains. This county takes the lead in water supply and position, since the valley is 10 miles wide and 20 miles long, runs north and south, and is watered by the Jordan and by numerous large streams that flow down from the heart of the Wasatch. There are also a few streams flowing from the Oquirrh Mountains. Throughout the lower part of the valley thousands of artesian wells are flowing. The soil is sandy in the upper and clayey in the lower part of the valley. The elevation is 4,215 to 4,500 feet above the sea. The area of the county is 614,400 acres. The cultivated land is 38,587 acres. The water supply is 365.5 to 425.5 cubic feet per second, all in use. The irrigating season is one hundred and twenty-two to one hundred and fifty two days long, and the duty of water is about 1 cubic foot to 80 or 100 acres. The rain-fall during the irrigating season is only 7.882 inches, being more than double that in many other parts of the Territory. There are 13,668 acres of lucerne raised; hay, 2,215 acres; small grain, 13,566 acres; roots and vegetables, 3,470.5 acres, and fruit, 1,628.5 acres. There are thirty-seven canals with an aggregate length of 213.8¾ miles. There is enough water running to waste outside of the irrigating season to redeem 44,000 acres. There are eleven reservoir sites in the mountains reported in detail, aggregating 50,250,000 cubic feet, and several others of good size not reported. There are four sites reported in the valleys, and one of them, Utah Lake, if raised 2 feet would irrigate 53,000 acres, and if raised 5 feet would irrigate 133,000 acres. But this lake can never be filled in a dry season; the total inflow last winter was only enough to raise the lake a foot, and for other reasons hereafter given it will never cut much of a figure as a reservoir. The average depth of snow in the mountains is 4 to 10 feet. The relative humidity for the year is 48.3 per cent.; during the irrigating season it is 42.3 per cent. The annual temperature is about 51.2 degrees.

Utah County.—This county lies chiefly in the beautiful Utah Valley with its large fresh-water lake in the center, 80,000 acres in area. Most of the arable land is in this valley, but there is considerable arable land on the Spanish Fork River. The elevation is about 4,600 to 4,800 feet above the sea. Though it is some higher than Salt Lake Valley it is nearly as warm, because of sloping toward the sun. The area of the county is 1,344,000 acres, of which 69,126 acres are cultivated. The irrigating season lasts about 122 days. The duty of water is reported as 40,000 cubic feet per year, but it is probably not less than 1 cubic foot per second for 100 acres. The water supply comes from fourteen streams and one river, whose flow in July was 308 cubic feet per second. There are sixteen canals reported; length, 66.2 miles. There are many artesian wells in the valley. They lost 28,985 acres of crops this year by lack of water. There are eight reservoir sites given in detail in the mountains and two in the valleys; capacity 791,000,000 cubic feet. There are five additional sites given in the valley and nineteen in the mountains; capacity not specified. Enough water runs to waste to irrigate 50,000 acres. About the same amount of rain falls here as in Salt Lake Valley. The average depth of snow in the mountains is 4 feet. The soil in this county is mostly sandy. Along the Spanish Fork River are many farms with an elevation of 5,500 to 6,500 feet above the sea whose supply of water could be greatly increased by deep artesian wells.

Wasatch County.—This lies east of the Wasatch, and the inhabited portion is west of the Coal range, being south of Summit and east of Utah County. The settled part is a triangular valley at the eastern base of the Wasatch, called Provo Valley,

since it lies along the Provo River. This is some 6,000 feet above the sea, has 18,000 acres of cultivated land, and 32,000 acres that could be reclaimed by more water. The water supply is not given, but one-half the crops were lost this year by lack of water. There are 14.5 miles of canals reported. Five reservoir sites are reported, capable of irrigating 14,000 acres. This valley raises small grain and hay chiefly. Water storage is a necessity if the present acreage is to be preserved, to say nothing of extending it. The greater portion of this county of 1,344,000 acres lies east of the Coal range on the reservation. There are hundreds of acres there that produce abundant crops of hay when stock is kept off from them.

Uintah County.—This county is situated east of Wasatch, Summit, and Emery Counties. It is mostly an Indian reservation; but just south of the Uintahs is a small cultivated area not on the reservation. The area of the whole county is 4,000,000 acres. The cultivated area is 8,932 acres. The soil is partly sand and partly clay. The elevation of Ashley Valley runs from 4,400 to 5,000 feet. The irrigating season is from 178 to 198 days long, and the duty of water is given as 20,000 to 50,000 cubic feet per acre, but this is doubtless far too small. It takes a trifle more water for clayey than for sandy soil. It takes the same amount of water for small grain as for lucerne, a trifle more for root crops, and one-half as much for orchards. There were 970 acres of crops lost this year from lack of water. The average depth of snow in the mountains is 6 feet. Several good reservoir sites are mentioned. The supply of water in Green River is unlimited, and much land could be reclaimed by proper dams in this river. The supply of water on Ashley and Brush Creeks is quite limited, but could be greatly increased by reservoirs.

San Pete County.—This county occupies an elevated valley between the Wasatch and Coal range, and south of Utah County. It is the valley of the San Pitch River and a part of Thistle Valley. The former runs southward from the head of Thistle Creek for 45 miles till it joins the Sevier Valley. The elevation is perhaps a thousand feet or more higher than Salt Lake Valley, and the rain-fall is less. The water supply come from both sides of the valley in numerous small streams, but the greater number come from the east. This has been called the granary of Utah. The chief product is small grain. The irrigating season lasts 107 to 183 days. The duty of water is about 1 cubic foot per second to 90 acres. Each acre is irrigated 120 hours. Many acres of crops were lost this year through lack of water. The average depth of snow in the mountains is reported as 6 feet. Several reservoir sights are mentioned. The area of this county is 1,164,800 acres. The amount under cultivation is not reported.

Sevier County.—This county occupies the southern part of the great valley which lies east of the Wasatch and west of the Coal range, running from Thistle on the north to Panguitch on the south. This great valley, over 125 miles long, is called the San Pete on the north and the Sevier on the south. It is lowest in the middle where the southward flowing San Pitch and the northward flowing Sevier Rivers unite, and breaking through the Wasatch pass out westward upon the desert in Millard County. The only arable land in this county lies in the Sevier Valley, which in this county is several miles wide and 50 miles long. It is watered chiefly by the Sevier River, but there are many small streams and springs coming from the mountains on either side. The river measured 70 cubic feet per second at Joseph City on July 26, 1889. No other measurements are reported. There were reported eleven canals aggregating 107.5 miles in length. The area of the county is 993,280 acres, of which 25,000 acres are under cultivation; all but 7,000 acres are watered by the Sevier River; 100,000 acres could be irrigated if there were more water. There are 2,634 acres of lucerne raised, 11,982 acres of small grain, 710 acres of root crops and vegetables, and 178 acres of orchards. The elevation of the lower part of the valley is about 5,500 feet and the irrigating season is 244 days long. Some fruit is raised here. The upper part of the valley is from 6,000 to 7,000 feet above the sea, the irrigating season is 122 days long, and small grain and hay are the chief products. The soil is sandy and very productive. There are none of the thinly populated counties that have such possibilities before them as this; for there is enough water to irrigate the whole valley if it is properly stored. The depth of snow in the mountains in winter is about 6 feet. Six reservoir sites of great capacities are reported in the mountains. All the present water supply is utilized. Deep artesian wells are possible in some parts of the valley.

Pi Ute County.—The cultivated portion of this county lies in or near the heart of the Beaver Mountains, south of Sevier County, and at the junction of the Coal range with the Wasatch. The valleys are elevated and cold, being 5,400 to 7,000 feet above the sea. The irrigating season never exceeds one hundred and seventy-three days. The duty of water is not more than one cubic foot to 100 acres. The land is irrigated from twenty to forty-eight hours per annum. The water supply is 217 cubic feet per second; comes from eleven creeks and rivers, and in some localties is not all in use, while in other places 400 acres were lost and many more injured by lack of water. There are 31 canals. Ten reservoir sites are reported of such capacity as to irrigate

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15,000 additional acres, more land than there is to cultivate. The average depth of snow in the mountains is 4 to 5 feet. The area of the county is 2,368,000 acres. The cultivated area is 12,135 acres, lying in Sevier, Grass, and Rabbit Valleys. But little fruit is raised in this county.

Garfield County.—The western part of this county also lies in the heart of the Beaver Mountains, and its cultivated valleys are all elevated 5,835 to 6,273 feet above the sea and cold; best adapted to hay and grain. The irrigating season lasts ninety-seven days, and the duty of water is slight; the land is irrigated but twenty-five days during the year. The water supply is not given. There are 34 canals. The area of the county is 2,892,800, of which about 5,000 acres are cultivated. Four reservoir sites are definitely reported, and many others are mentioned; enough to irrigate several times all the arable land in the county. Some of these sites could be used to help out Kane and Washington Counties.

THE DRY COUNTIES.

The larger part of these counties is arable land, and can never be reclaimed because of being destitute of any water, either present or prospective, while the eastern edge of these counties might almost be classed with the moist group.

Box Elder County.—This county lies in the northwest corner of the Territory and is the least arid of them all. The western portion has a few farms and some meager streams, while that portion next to the lake is susceptible of artesian wells and is quite productive. The mountains in this portion are so low and lose their snow so early that water storage is out of the question.

Tooele County.—This county lies west of Great Salt Lake and Salt Lake County. It is very large, containing 4,140,800 acres, of which only 6,250 acres are cultivated, and these lie chiefly in one valley (Tooele). This valley is a broad one, lying between the Oquirrh and Aqui Mountains, from which it receives its water in eight small streams aggregating 78¼ cubic feet per second. These mountains do not rise high enough to give water all the season. This valley is being greatly developed by artesian wells. Rush valley is a magnificent one, being the southern extension of Tooele Valley. There are 200,000 acres that could be redeemed here alone, but there is no surface nor artesian water to be had. Reservoirs might catch some water. Skull Valley is another large tract lying directly west of the Aqui Mountains This is capable of artesian wells, and has a small supply of surface water. It is undeveloped. On the western edge of the county near Deep Creek is some cultivated land. There are 1,000,000 acres of good land that could be redeemed if there were water for it, but by fully developing all resources by storage and otherwise 100,000 acres is an outside limit of the acres that will ever be cultivated in this county with the present rain-fall. The elevation of the valleys is 4,400 to 5,000 feet above the sea. All kinds of fruit and produce can be raised here that are raised in Salt Lake County. The duty of water is 1 cubic foot per second to 80 acres, and the irrigating season runs from 122 to 200 days. Several good reservoir sites are reported. The average depth of snow in the mountains bordering Tooele Valley is 3 feet. The soil is so gravelly near the mountains that fully one-half of the water is lost by seepage before it gets to the fields. Water storage and fluming the canals are the crying needs of this county.

Juab County.—This county lies south of Tooele and runs from the Wasatch to the western boundary. The area is 2,457,600 acres, and fully one-half of it is level land that could be redeemed by water, but outside of artesian wells there is no hope for most of this county. Four thousand acres are reported under cultivation beneath the shadow of Mount Nebo. All kinds of fruit and grain are raised here that the Great Basin produces. The elevation of the valleys is from 5,000 to 5,500. The average depth of snow in Mount Nebo is 3 feet. Several good reservoir sites are reported. Nearly one-half of the crops were lost this year by lack of water. Water storage and artesian wells are the only hope of this county.

Millard County.—This county lies south of Juab and runs from the Wasatch to the western boundary. This is one of the largest counties in the Territory and has the largest amount of arable land of any, if there were only water for it. The area of the county is 4,492,800 acres, and over one-half of it is good land. Artesian wells are being developed in this county, but generally the flow is so slight that the water is valuable only for drinking. The settlements lie along the western base of the Wasatch and along the Sevier River. They are from 5,000 to 6,000 feet above the sea, and produce large quantities of fruit, small grain, and lucerne hay. The irrigating season runs from 90 to 122 days. There are 13,500 acres reported as under cultivation; 1,000 acres were reported as lost and much more as injured by lack of water this year. The soil is sandy near the mountains and clayey in the Sevier Valley. There are 42 miles of canals reported. Water storage is not only an imperative necessity in this county, but it is practicable. Much water runs to waste in the Sevier River; probably triple what is used. There are many good sites along the

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river where from 1 to 3 square miles of water several feet deep could be held back. Back of Scipio a natural lake, now used as a reservoir, could hold 5 square miles of water of considerable depth. It is said that the Sevier River could be turned into it. There are several good sites in the Wasatch.

Beaver County.—This county has an area of 1,689,600 acres, of which one-fourth is good land; 9,500 acres are reported under cultivation. This county lies south of Millard and runs from the Wasatch to the western boundary. The upper valleys are 6,000 and the lower about 5,000 feet elevation. The irrigating season lasts ninety-one to one hundred and twenty-two days. The land is irrigated twenty-nine to thirty-two hours per year. There are 45 canals; length not given. The settlements lie chiefly along the Beaver River and its tributaries. The average depth of snow in the mountains is reported as 8 feet. The Wasatch here rises to a great height and snow lies on the mountains all the year round; 25 reservoir sites are reported in detail, aggregating 17 square miles, sufficient to irrigate 20,000 acres at least; about 10 of these reservoirs are in the valleys and the remainder in the mountains.

Iron County.—This county lies south of Beaver, on the rim of the Great Basin, running from the Wasatch to Nevada. Its area is 2,102,400 acres, and nearly half of it is arable land, some of it capable of artesian wells, but most of it destitute of water; 6,997 acres are reported under cultivation. The irrigating season is given as 142 to 269 days. The elevation of the valleys runs from 5,400 to 6,100 feet above the sea. The duty of water is given as 1 cubic foot to 65 acres in the more arid valleys and from 160 acres to more than double that in the moist valleys. The water supply comes from 8 small streams, capacity 67.63 cubic feet per second. The land is irrigated from fifteen to forty-two hours per year. If the water could be saved, from 10,000 to 20,000 acres could be redeemed; 14 reservoir sites are reported in detail. Water storage is the only means of developing the agricultural resources of this county. The soil is chiefly clay.

Emery and Uintah Counties.—To this group belong parts of these two counties, which lie between the Green and Grand Rivers. There are many thousands of acres of clayey soil that could be reclaimed by great canals running from these rivers, whose unlimited water supply, greater than all the rest of the Territory put together, will run to waste without assistance is given in constructing such canals. There is no part of the Territory that needs developing more than this. Very deep artesian wells might be successful here.

Emery County.—But a small part of this county belongs to the Dry Counties, still nearly all of the cultivated area lies in that section on the extreme western side of the county. This lies directly east of San Pete and Sevier Counties at the foot of the Coal range. The rain-fall does not exceed 10 inches per annum. The water supply comes from four creeks and one river, breaking through the precipitous eastern face of the Coal range in narrow cañons. The flow of water is 171.15 cubic feet per second. The area of the county is 5,603,680 acres. The cultivated land is 14,825 acres. The soil is a very refractory clay. The duty of water is 1 cubic foot to about 35 acres. Castle Valley is 4,500 above the sea, and the irrigating season is 229 days long. Little Grand Valley is 3,900 feet above the sea, and its irrigating season is 244 days long. There are 34 canals; length not given. One-quarter of the crops was lost this year through lack of water. All the water is in use. The average depth of snow in the mountains is 4 feet. Twelve reservoir sites are definitely reported, and many others are mentioned. There is enough storage to use double the total water supply. Probably 10,000 to 15,000 acres more could be irrigated by saving the waste water. Great suffering often results from scarcity of water in this county. All kinds of crops are raised in this county, even sugar-cane, fruit, pea-nuts, etc. Figs could be raised in the hotter portions.

THE HOT COUNTIES.

These counties are far more arid naturally than the dry counties, since they are farther from the lofty mountains, and most of the arable parts are 2,000 or more feet lower, lying in deep valleys shut out from winds and surrounded by great fields of lava with red hills and a red, sandy soil of unknown depth. The heat here is almost unendurable and the rain-fall is almost nothing. This region is valuable for the fruit and cotton that it raises.

Washington County.—This county is situated in the southwestern corner of the Territory. The area is 1,649,920 acres. Of this, 18,892 acres are cultivated. These are situated along the Virgin River or its tributaries chiefly. It is estimated that 18,900 acres could be redeemed by an increase of the water supply. The lower valleys are 2,700 and the upper 4,000 feet above the sea. In the lower valleys the irrigating season is 197 to 228 days long, in the upper 122 to 177 days. The water supply comes from the Virgin River, four streams and many springs, capacity 191.8 cubic feet per second. In the lower valleys the land is irrigated 84 to 90 hours per year, and the duty of water is 1 cubic foot per second to 20 acres. In the upper valleys the land

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is irrigated 26 hours per year and the duty of water is 1 cubic foot per second to 60, 80, and 128 acres. There are 31 canals; length not given. One-third of the crops were lost this year by lack of water. It is probable that water enough could be stored to redeem most of the arable land in this county. Vast quantities of water go to waste in the Virgin River in the winter and flood time in spring. The depth of snow in the mountains is 2 to 6 feet. This county raised 30,000 pounds of cotton last year. The Sultana seedless grape is grown here and produces from 3,000 to 5,000 pounds of the finest quality of raisins. Both the hard and soft shell almonds are raised in quantities here as well as figs. It is believed that oranges can be raised here. Olives are grown in this county. Peaches and apricots from this region are very fine. They raise 4 to 5 crops of lucerne per year. A crop of small grain and another of corn are raised from the same land.

Kane County.—This county is more rugged than Washington and more elevated except along the Colorado River. It lies east of Washington. The area is 2,659,200 acres, of which 1,825 acres are cultivated, and 13,350 acres are said to be arable. The irriga ting season is 182 days long, and the duty of water is from 37½ to 75 acres to the cubic foot per second. The water supply, exclusive of the limitless Colorado River, is 31 cubic feet per second. There are nine canals; length not given. The crops are greatly damaged by lack of water. Sufficient reservoir sites are reported to irrigate all the arable land in the county. The average depth of snow in the mountains is 4 feet. The crops in this county are much the same as in the foregoing, though more small grain and hay are raised in proportion to the area cultivated.

San Juan County.—This county lies in the southeastern corner of the Territory. Most of it is now proposed to be made an Indian reservation. Its area is 5,809,920 acres. There is a narrow strip of land along the Colorado and San Juan Rivers that will produce the crops of Washington County, and has an unlimited water supply. Most of the cultivated area is 5,000 feet above the sea, near the La Sal Mountains. There are 1,025 acres cultivated. Dry farming is successful in some localities in the mountains. There are good facilities for storage of water.

Other counties.—Small parts of Garfield and Pi Ute Counties situated along the Colorado are capable of raising the same products as Washington County.

To sum up we find there are about 500,000 acres of land under cultivation at the present time. This area could be doubled from the present canals if there were more water and by new canals, etc. The various counties estimate that about 3,500,000 acres could be redeemed. This is doubtless three and a half times too large. The average depth of snow in the mountains is 4 feet. The length of the irrigating season in the moist counties is one hundred and fifty-two days; in the dry counties it is about the same in cultivated areas; in the hot counties it is about two hundred days. The returns are very unsatisfactory in this respect and must be wholly revised. The duty of water is about 80 acres to the cubic foot per second in the moist counties, in the dry counties it is uncertain, and in the lower hot counties it is about 20 acres. The water supply is about 3,000 cubic feet per second for the moist counties, 250 for the dry counties, and 250 for the hot counties; total 3,500 cubic feet per second. This is probably our minimum water supply throughout the dryest years in the counties reported. If we were to add the supply in the Green and Grand Rivers this amount would be more than double. Almost all of the present supply is appropriated during the irrigating season and our Territory must remain at a standstill without water storage. There are 150 reservoir sites reported in detail and nearly as many more mentioned. They vary in capacity from 130 square miles to 1 acre, and from 2 feet to 100 feet deep. About one-third of the crops were lost this year through lack of water.

Utah, Nevada, and Arizona are the most arid portions of the United States, and therefore the preservation and economical use of all their water supply is an imperative necessity. To show how we differ from Colorado and the East, I have prepared a diagram of the average monthly rain-fall of Salt Lake City for thirty-three years, and of Denver, Colo., and Des Moines, Iowa, since the beginning of observations there

During the irrigating season here Des Moines, a place where irrigation is not necessary, has a rain-fall of over 2 acre feet and Denver almost 1 acre foot, while Salt Lake has less than two-thirds of an acre foot, which would make a difference of about 11,000 cubic feet to the acre, which must be made up by that much more water from the streams to irrigate our land as well as that of Colorado is irrigated. But during the same period the relative humidity of Denver is 3 degrees higher and the temperature 2 degrees lower, which would greatly increase the amount of water required to irrigate an acre of land in Utah in proportion to that of Colorado. Besides this, Denver is nearly 50 miles from the crest of the mountains, from which a part of its moisture is derived, while Salt Lake City is but 10 miles and has a lake of 2,000 square miles in area within 7 miles on the other side. These things make Denver fairly representative of northern Colorado in general, while they show Salt Lake City as the place with at least 50 per cent. more rain-fall than the rest of the Territory (save the

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mountains themselves) and with a very abnormal humidity. Therefore what applies to Salt Lake in the great amount of water required per acre will apply with redoubled force in the dry and hot counties.

We have had evaporating pans located in various parts of the Territory for the last two months, and though these were of necessity placed out of the reach of the wind the evaporation averaged three-tenths of an inch per day, often running up to five-tenths of an inch. Had they been placed where the wind could have reached them the evaporation would have equaled 15 inches per month. The enormous drain upon our water supply can therefore be well understood. This militates against shallow reservoirs in the valleys. If Utah Lake were raised 3 feet its water would all be evaporated during the irrigating season if none flowed in or out. Enough to irrigate 83,000 acres would go up in the air. From records kept in the mountains the evaporation there during the same period was only eight-hundredths of an inch, and never exceeded seventeen hundredths per day. Therefore reservoirs in the mountains are at least four times as valuable as those in the valleys. We do not yet know the rain-fall in the heart of our mountains, but it will not fall far short of 40 inches nor more than 60 inches per annum. It should be observed that though we have 2 inches more rain-fall in Salt Lake than in Denver, yet but 46 per cent. of it falls during the irrigating season while 73 per cent. of Denver's rain-fall comes when it is needed most.

The possibility of reclaiming Utah by artesian wells has been greatly overestimated. All the wells so far obtained have been found in some one of the basins of the ancient lake of which Great Salt Lake is the saline remainder; the area of that lake never exceeds 18,000 square miles. The clay sediment from that lake makes the impervious cap of those subterranean reservoirs, whose rims are but slightly elevated above the villages, and the reservoirs are fed from the bases of the mountains where the surface water runs over the gravel débris between the mountains and the clay rim. The average depth of these artesian wells in Salt Lake Valley is about 100 feet, in Utah Valley 200, and in Tooele about the same. In Millard County a few wells have been driven with a depth of about 200 feet and a flow of one-half to 10 gallons per minute through 1¼ inch pipe. Since no solid rock is struck in driving these wells they are very liable to clog up in a few years. The flow in Salt Lake Valley will not average 25 gallons per minute, though some wells far exceed that. A well flowing 5 gallons per minute will irrigate an acre of ground.

ARIZONA AND ITS IRRIGATION CHARACTER.

Turning southward, Arizona is found to be making considerable progress. The southern, or Gila Valley portion of the Territory, and its smaller central valleys, offer a considerable area for the farmer when irrigation is applied. The difficulties of the problem are found not only in the newness of the region, as to settlement, but in the want of system and the confusion of ideas as to the lawful use and control of water. The Mormon system would probably bring about in both Arizona and New Mexico the same admirable results that it has secured in Utah. It is estimated that there are in the Territory about 2,800,000 acres of land of the best quality, with surface water sufficient to irrigate the same by a reasonable expenditure on ditches. Of the above area not quite 300,000 acres are in cultivation. There are at least 10,000,000 acres of rich land that could be reclaimed by means of artesian and other wells, if they can be obtained.

For convenience of arrangement in considering its agricultural capabilities, Arizona may be divided into: (1) The Colorado Valley; (2) the valley of the Gila and those of its tributaries, including the Salt River as far north as the thirty-fifth parallel; (3) the Santa Cruz Valley, the isolated locations of Pinal and Pima Counties, and the vicinity of the New Mexico line; (4) the Colorado Chiquito Valley; (5) the southwestern portion of Yavapai County, surrounding Prescott, and the valley of the Rio Verde, with its tributaries.

In one of Lieutenant Wheeler's reports of exploration in Arizona, California, and Nevada, a comparison is made between the capabilities of certain portions of the Territory and those States, which brings to light some important facts. The Arizona portion compared is bounded

in longitude by the meridians of 111 degrees and 113 degrees 45 minutes, and in latitude by the parallels of 34 degrees and 35 degrees 40 minutes, which include the southwestern portion of Yavapai County and a small strip of Mohave County, by no means the best agricultural region of the Territory, and scarcely up to the average. This is compared with the eastern portion of southern California, and the southern portion of Nevada, in the same latitude:

	California and Nevada.	Arizona.
	Per cent.	*Per cent.*
Agricultural, irrigable, and arable land	2	25
Timber	6	10
Grazing	88	30
Barren	4	35

In the Colorado Valley the soil is rich in the chemical combinations requisite for fertility, and only in small patches contains too large a proportion of clay. In some places it has also small amounts of chloride of sodium and sulphate of lime. The fertilizing reddish mud resembles that of the Rio Grande and of the Nile, and its quantity varies from 0.1 to 0.5 per cent. (1–1000 to 1–200) of the water, which is good to drink even when considerably colored by the mud. As compared with the aboved-named rivers, it contains less potassa, more phosphoric acid, and much more carbonate of lime, the presence of the latter valuable ingredient being due to the immense limestone beds through which the river flows in the upper part of its course.

The following table (mud from the Colorado having been collected) exhibits a comparative analysis of the mud of these rivers:

	Colorado.	Rio Grande.	Nile.
Hygroscopic water	3.27	1.890	.....
Chemically bound water, soluble in hydrochloric acid	1.14	3.122	.....
Potash	0.103	0.284	0.166
Soda, with trace of lithia	0.074	0.064	0.022
Lime	.....	1.479	1.725
Carbonate of lime	12.50	5.190	.....
Magnesia	0.69	0.080	0.046
Oxide of iron	.....	3.640	8.804
Alumina	2.26	1.308	
Phosphoric acid	0.146	0.092	0.143
Sulphuric acid	Trace.	Trace.	Trace.
Oxide of manganese	Trace.	.....	.....
Insoluable in hydrochloric acid	78.1	82.55	.....

As to the extent to which the Colorado River could be rendered available for irrigation, it has been appropriately remarked by geologists that the country bordering on the Colorado is the most conspicuous example in the world of overdrainage; for nowhere else do we find a stream that for hundreds of miles cuts its way 500 to 600 feet deep through solid rock. The Colorado, supplied by streams from the mountains, where rain and snow are abundant, cuts its way through a rainless, and therefore desert, region, in which the only changes are those resulting from the direct action of the atmosphere, so that no appreciable débris of any kind is furnished to fill up the excavations continued through millions of years, and only limited by an approximation of the level of the river-bed to that of the waters of the Gulf of California.

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Lieutenant Wheeler estimates the area of land drained by the Colorado River and its tributaries to aggregate 242,065 square miles, mostly still owned by the Government.

The Salt River Valley is 25 miles in length by about 14 in width. With its estimated 250,000 acres of rich, alluvial soil, capable of producing 25 to 50 bushels of grain to the acre, it ought easily to support 50,000 inhabitants, if there were a sufficiency of irrigating ditches and artesian wells to fully utilize its natural capabilities.

The valley of the Gila, though cultivated along most of its course, is not available for semi-tropical productions in its upper part on account of October frosts. The White Mountain Indian Reservation (San Carlos) interferes with a continuous white settlement above Florence, as the lands of the Pimas and Maricopas do below it. These latter Indians have cultivated wheat, corn, pumpkins, melons, etc., for centuries, and have always been self-supporting, as well as the Papagoes, farther south, who, however, depend principally on stock.

The Gila bottom merges imperceptibly into the foot-hills, and has an average breadth of from 5 to 10 miles. Its soil is principally alluvial, and will produce two crops yearly. Irrigation is easily effected. The river averages 600 feet in width, and is 3 to 5 feet in depth when there is no rain-fall and no water from the mountains. The banks along the whole of this tract are so low and sloping as to afford unusual facilities for the construction of ditches. Excellent crops of wheat, barley, and vegetables are grown. In the vicinity of Florence is an extensive tract of rich bottom and second-mesa or table-land, on which are now grown the cereals, alfalfa, the sugar cane, and vegetables and fruits generally, including orange and lemon trees. Fruit culture in the Gila Valley is extensive. Cottonwood, ash, and locust are abundant. Farther up the valley the Pueblo Viejo has, with its tributary valley of Ash Creek and others, at least 100,000 acres of good farming land.

On the uplands and farther up the valley itself, near the line of New Mexico, the daily variations in temperature are much less and the frosts begin later. Still farther up its course, within the borders of New Mexico, the Gila River has upon its margins much good agricultural land. The bottom-lands generally are quite rich in potassa and phosphoric acid.

The valley of the Francisco River, a tributary of the Gila, near the line of New Mexico, is good for grazing and timber, and has in general a rich soil. The San Pedro River is a tributary of the Gila, its mouth being between Florence and San Carlos, and its source in the Huachuca Mountains, near the Mexican line. There is good land, good timber, and excellent range for stock. Considerable valley land is now under cultivation, and irrigation is generally required.

The Santa Cruz Valley, though smaller in extent, is equally productive in proportion to its area. It is more compact, and all of it is adapted to semi-tropical fruits, as well as to the vegetables of the temperate zone.

According to information received, about 250 miles of main canals have been completed during the past two years, or are under rapid construction. With the tributary feeders and laterals southern and central Arizona now has completed, or very nearly so at least, about 700 miles of irrigation works. As this Territory has always been considered one of the most unpromising in the dry and mountain regions of this country, these facts are of a cheering character. The most astonishing reports are made of the fertility of the areas "under water."

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RAINY SEASONS AND PRODUCTION.

The physical configuration of Arizona shows it to be, as already stated, an overdrained region. This is in itself sufficient to account for the unquestioned aridity of a large portion of the Territory, but settlement and time are proving there, as well as elsewhere within our mountain area, that the supplies of water, with proper conservation and distribution, will be found more important and available than has generally been considered at all probable. In the narrow and precipitous valleys of Central Arizona there are natural reservoirs, of which, with comparatively little outlay, valuable storage basins may be created and force obtained to raise the water high enough for reaching extensive portions of the mesa or table-lands adjoining the river valleys. Several of the minor streams are known to sink, and their recovery and use for industrial purposes will be found a task not difficult to engineering skill.

There are two rainy seasons, in the winter and summer months respectively. In the summer the rains are often violent and torrential in character, disappearing almost as suddenly as they come. In April and May there are often neighborhood showers, seeming to be limited in area, as if the currents in their passage from the Southern Pacific, coming through the Gulf of California, were broken by the higher peaks and whirled in circular eddies over the sections visited. They are known by the Mexicans and Indians as "shepherd rains."

The population is rapidly increasing, especially in the southwestern and central portions of the Territory. The immigration into these sections aggregates 5,000 persons yearly, and the increase for the Territory for the last ten years will average fully 10,000 per annum. The returns from the different counties to the Territorial auditor for the present year show a total valuation of $27,231,424.47.

Arable land with water that sells at from $20 to $75 per acre is assessed at from $5 to $15 per acre. There are assessed 5,985,358 acres in the Territory, about 5,000,000 of which is embraced in the grant to Atlantic and Pacific Railroad, and assessed at 20 cents per acre, which is being sold at from $1 to $10 per acre. The entire valuation on land is $3,285,212.60, on landed improvements $1,931,440.83. There are assessed 552,718 head of cattle; the actual number in the Territory will fall a little short of 2,000,000. The estimated population is by counties as follows:

Yavapai	16,000	Cochise	14,000
Maricopa	16,000	Pima	14,000
Apache	12,000	Pinal	8,000
Mohave	5,000	Yuma	3,000
Gila	5,000		
Graham	12,000	Total	105.000

The lands covered by canals and ditches is in—

	Acres.		Acres
Apache County	6,900	Yuma County	40,000
Yavapai County	40,360	Pima County	7,500
Gila County	7,600	Cochise County	23,500
Pinal County	71,600	Mohave County	1,000
Graham County	47,000		
Maricopa County	321,000	Total	566,460

Of land requiring no irrigation the amount entered and occupied is estimated at 100,000 acres, lying principally in the counties of Apache, Yavapai, Graham, Pima, and Cochise, of which one-half has been cropped the present season.

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The value of the agricultural product varies according to locality. In this valley the Salt River hay is baled at $5 per ton; in Yavapai and Apache Counties at $20 to $25. Barley is worth here 75 cents per hundred; in other counties from $1 to $2.50. Fruit here is worth from $20 to $40 per ton; in other counties from $40 to $200. Land in alfalfa or grain here gives a return of from $15 to $25 per acre; in other counties from $30 to $50. Fruit in this and the Gila Valleys gives a return of $100 to $200 per acre, and in other localties more or less according to yield. The value of product from every acre of land cultivated in Arizona can safely be placed at $30, which will be largely increased in the southern valleys as the orange, fig, grape, apricot, and other fruit-trees and vines now being planted come into bearing.

The value of the products of the Territory for 1889 was as follows:

Agricultural and horticultural	$9,207,000
Live-stock—horses, sheep, and cattle	6,000,000
Gold and silver	4,431,500
Copper	2,000,000
Lumber, wool, etc	1,500,000
Total	23,138,500

In the Territory the amount of land that can be reclaimed through a proper system of reservoirs and canals, conserving the storm-water for irrigation, is very large, being variously estimated from 6,000,000 to 8,000,000 of acres, fully two-thirds of which, lying below the thirty-fourth parallel and not in the mountains, can be made available for the cultivation of those citrus and deciduous fruits that make horticulture most profitable in all semi-tropical countries.

Mr. Farish, immigration commissioner, from whose report the foregoing is condensed, testified as follows as to fertility:

We grow as fine lemons as you would wish. Along at Florence they have grown splendid olives. In this valley our olive trees are not far enough advanced to tell anything about; but they have grown them up there. We have planted out here some 22,000 orange trees, experiments in growing that have been successful. Peaches, pears, and apples are not so good. They grow to great perfection so far as size is concerned, but they lack flavor. We grow the crab-apple, prunes, and dates. Every variety of figs is a natural product here. The date is produced here seven years from the seed, and in bunches of from 5 to 25 pounds. And we grow wheat here—I should think about 1,800 to 2,000 pounds to the acre. The yield of barley is from 2,000 to 2,500 pounds to the acre, and sometimes as high as 3,000 and 4,000 pounds. Alfalfa is the principal crop. We cut that from three to four times a year, and we cut from 6 to 8 tons to the acre.

The total area of ditch construction and acreage under water is estimated as follows:

County.	No. of canals.	Length.	Area under ditch.
		Miles.	*Acres.*
Apache	.....	24½	12,500
Cochise	.....	51	8,300
Graham	.....	60	35,000
Maricopa	23	304½	194,400
Pima	36	52	30,000
Pinal	28	50	78,000
			* 50,000
Yavapai	.....	78	40,000
Yuma	10	120½	81,000
Total	.....	740½	529,200

* In Pima Reservation.

These figures are entirely taken from county reports. The ditch system constructing in Yuma County will, when completed, have a total

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length of 241 miles and an acreage of 207,000. The total cost will be $1,318,000, or nearly $5,500 per mile. The canals under way in Maricopa County will, when completed, cover 404,900 acres and have a total length of 425 miles. Apache County reports 150,000 acres reclaimed, Pima County 2,500,000 acres, and Cochise 310,000 acres. Of the area "under ditch" about two-thirds are actually cultivated.

THE FERTILE SALT RIVER VALLEY.

Maricopa County is the central and, agriculturally speaking, the most important section of Arizona. From a report the following statements are quoted:

In the Salt River Valley the following canals have been taken from the Salt River:

Name.	Length.	Name.	Length.
	Miles.		*Miles.*
Arizona	41	Utah	6
Grand	22	Farmers	5
Maricopa	14	Highland	22
Salt River Valley	18	Dutch Ditch	4
San Francisco	9	Monterey	4
Tempe	19	Griffin	3
Mesa	9		

These water-ways cover in the aggregate 250,000 acres of land, of which 187,500 have been reclaimed and 125,000 acres are annually cultivated.

On the Gila are the following canals which have been completed:

Name.	Length.	Acres.	Name.	Length.	Acres.
	Miles.			*Miles.*	
Buckeye	30	20,000	Gould & Bro.'s	8	3,000
Gila River	8	5,000	Palmer	22	12,000
Enterprise	12	6,000	Citrus	14	5,000

Besides which are the following canals now in process of construction: The monarch ditch, 8 miles long, which will cover 2,000 acres; the Gila River Irrigation Company, which takes the water at Black Butte, below the mouth of the Hassayampa River. The company have 12 miles of their canal completed and propose to put in a dam 1,755 feet long and 75 feet high, and carry the water south and southwest, taking in the entire valley on the south and east sides of the river to the line of Yuma County, making a canal 75 miles long and covering 500,000 acres. The Gila Bend Canal Company starts from Gila Bend on the south side of the river. They have completed 22¼ miles of the canal, which is to have a total length of 30 miles and cover 18,000 acres. Under this canal about 3,400 acres have been cultivated this season. The same company are building a large canal, taking the water about 2 miles above and running southwesterly a distance of 50 miles, intending to reclaim 80,000 acres, much of which has been filed upon.

Owing to the dryness of the atmosphere, the evaporation is very great in the valleys. During the summer months it will average about four-tenths of an inch every twenty-four hours, so that reservoirs sh ould, wherever possible, be constructed in the higher altitudes.

In the irrigation of lands it is the general policy of our people to flood them in winter, when water is abundant, which, by creating a reservoir of absorption, make frequent and heavy irrigations unnecessary during the months of June and July, when water is scarce. Since the first settlement of the valley of the Salt River the water has risen 30 feet nearer the surface. In some places fruits and alfalfa are grown without irrigation. It seems reasonable to suppose that when the lands on the high mesas along the foot-hill mountains are more generally cultivated the area of land requiring no irrigation will be very largely extended. Another fact is noticeable: The water used in irrigation, except that lost by evaporation, percolates through the soil and finds its way back to the river. More water flows into the Gila from the Salt River in the dry season, covered by the months of May, June, and July, than before the first canal was built in the valley. Forty miner's inches of water is calculated to make a cubic foot flow per second. One miner's foot is sufficient to cultivate 3 acres in grain or alfalfa, and 5 acres in fruits or vineyard.

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The principal grain crops of the county are wheat and barley. The past season there has been produced about 40,000,000 pounds of barley and about 30,000,000 pounds of wheat. The yield of wheat is from 1,200 to 1,800 pounds per acre, and of barley from 1,800 to 3,000 pounds per acre. Sorghum and sugar cane are grown to a considerable extent for the sugar they contain and for feed. Corn is not extensively raised, being confined to a few hundred acres each year. Oats are a native of the soil, and are cut in quantities evey year for hay. Timothy, Bermuda, and blue grass do well, but alfalfa is the principal grass grown. Once rooted, it requires no attention except to irrigate it three or four times during the year; grazed, an acre will support two and a half head of horses during the year, and from ten to twelve head of sheep or hogs. It can be cut from four to five times annually. and yields from 6 to 8 tons to the acre The hay is very nutritious, and as a pasture for all kinds of stock can not be surpassed. Three and four year old steers driven from the ranges upon alfalfa pastures gain, if poor, two pounds per day for the first three months, becomming at the end of that time, most excellent beef in any market.

The mesquite and cottonwood are native trees, but the ash, cork elm, pepper tree, catalpa, willow, umbrella, lombardy poplar, North Carolina poplar, mulberry, palm, magnolia, locust, and tamarack have been introduced with marked success.

Up to five years ago very little fruit of any kind was grown in the county, and that only by way of experiment. Since then the planting of orchards and vineyards has increased every year. It has been fully demonstrated that no better section exists for the growing of nearly all citrus and deciduous fruits. In the Lower Gila Valley lemons, oranges, figs, grapes, and pomegranates can be grown in great perfection, but it is not well adapted to the culture of other fruits. In other portions of the valley, and through the valley of the Salt River, peaches, pears, apricots, pomegranates, figs, French prunes, apples, oranges, almonds, quinces, dates, blackberries, and strawberries, and every variety of grapes, grow in perfection.

There are now planted through the Salt River Valley 8,000 acres in vineyard and 3,000 in orchard trees. Of oranges 200 acres are in cultivation; from experiments made the growing of this fruit will be a success. Olives have been planted in an experimental way. It is too soon to speak confidently as to the results, but as they have been successfully cultivated near Florence, in Pinal County, there seems to be no reason to donbt that good results will attend their culture in this county. Apricots, peaches, and kindred fruits bear heavily, yielding from 300 to 500 pounds per tree. Vineyards in full bearing give from 6 to 8 tons to the acre. Raisins have not yet become an export commodity with us, but will be in a short time; the muscat of Alexandria grown in this valley contains a greater quantity of saccharine matter than elsewhere, and from experiments made in raisin making we are justified in the statement that 3 pounds of this grape will make 1 pound of raisins, which is greater than in any part of this habitable globe. Another advantage which our county has in the prosecution of this industry over raisin districts of Spain or California is that the drying and curing can be done in the open air without damage from rain or dew.

Some experiments have been made in the manufacture of sherry wine, with satisfactory results. All our wines have a strong sherry flavor, and expert viticulturists who have examined into the matter claim this to be the only port and sherry district in America. On this subject the Hon. J. De Barth Shorb, commissioner at large of the State Viticulturist Society of California, writes: "I directed what should be done with one barrel of so-called white wine, from the Salt River Valley, as a matter of experiment, and upon examination a few months later, found, as anticipated, it had turned into a sherry of most excellent quality. I have no hesitation in saying that the Phœnix country is the only port and sherry country in America; so far as known, and with trained judgment in the selection of proper varieties of grapes adapted to your conditions, wines of the highest commercial value, if scientific methods be substituted for those now in vogue in the manufacturing of the wines, will be the inevitable result."

The growing of early and late vegetables will also, when railroad facilities are general, be a source of great profit to the people of this country—a country that produces fresh fruits and vegetables every month in the year; where grown in the open air peaches, figs, tomatoes, and cantaloupes can be gathered in December, and where the soil, a rich alluvial, varying in depth from 10 to 12 feet, inexhaustible in its durable fertility, will assuredly be the center of a great and prosperous community. Such are the mesa lands of this county. When reclaimed all vegetation has most rapid development.

The cottonwood and North Carolina poplar grows from 18 to 20 feet in a season, fruit trees from 12 to 15 feet, grape-vines from 25 to 40 feet.

The Indians occupying a reservation in this county have cultivated their land for two hundred years without apparent injury to the soil and without change of seed. After their crude method of farming they raise better crops of grain than are harvested in any of the wheat-growing districts in the Mississippi Valley.

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COLORADO AND IRRIGATION.

Colorado is as notable for the physical data it offers in relation to irrigation as it has already been shown to be in the legal aspects thereof. Prof. L. G. Carpenter, of the State agricultural college, reported in January, 1890, the following as the

Approximate areas "under ditch" in Colorado.

	Area.	Total area.	
	Sq. miles.	*Sq. miles.*	*Acres.*
Division I (Platte Division):			
Platte Valley, below the Poudre	283.21		
Platte Valley, above the Poudre, including Bear and Clear Creeks	551.64		
St. Vrain and Boulder Creeks	294.59		
Big and Little Thompson	134.22		
Cache La Poudre	393.54		
Total from South Platte		1,657.20	1,060,608
From North Platte in North Park		101.23	64,787
Division II (Arkansas Division):			
East of Huerfano River	489.08		
Cucharas	94.40		
La Veta and Apache	84.17		
Upper Arkansas and Fontaine	106.91		
		774.56	495,718
Division III (Rio Grande Division)		1,564.00	1,000,960
Division IV (San Juan Division), including Dolores, Mancos, Pine, Florida, La Plate Rivers		135.00	86,400
Division V (Grand River Division)		210.00	134,400
Division VI (Bear and White River Division)		110.00	70,400
Total		4,552.00	2,913,273

By this table the total amount of land under ditch in Colorado at present is not far from 4,500 square miles, or 3,000,000 acres. The amount of land actually irrigated can not be so reliably estimated at present. It is much less than that under ditch.

Professor Carpenter estimates the total irrigated as not over one-third. This is apparently below the actual results. State Engineer Maxwell had presented in September, 1889, the following figures as a careful statement of the area east of the Rocky Mountains:

Divisions.	No. of districts.	Miles of ditches.	Acres.	
			Under ditch.	Actually irrigated.
No. 1 Platte	14	2,067.36	1,126,800	631,036
No. 2 Arkansas	13	943.30	440,240	116,047
No. 3 Rio Grande	8	1,033.68	596,097	250,263
Total	35	4,044.34	2,163,137	997,346

In the three eastern divisions there are also one hundred and sixty-two reservoirs, with a record capacity of 5,319,939,788 cubic feet, capable of furnishing one acre-foot of water to each of 122,199 acres. The total number of ditches, large and small, in the State is estimated at 2,000, and their mileage at 5,000. The duty of water is placed at 1.45 cubic feet per second for 80 acres. In some sections it is over 100 acres, however.

The State engineer, Mr. Maxwell, has reported the following:

For the distribution, under the irrigation laws of this State, of the water from the natural streams to the irrigating canals, ditches, and reservoirs, the State is divided into six irrigation divisions and sixty-eight water districts.

In a general way, the first division comprises that portion of the State which is drained by the North and South Platte Rivers, the second division of that portion drained by the Arkansas River, and the third division of that portion drained by the Rio Grande.

These three divisions compose the "Eastern Slope," or all that part of the State which drains into the Gulf of Mexico.

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EASTERN SLOPE.

Tabulated statement showing the number of miles of irrigating canals and ditches, the number of acres of land under such canals and ditches, and the number of acres of land actually irrigated by such canals and ditches.

[Compiled from data in the State engineer's office.]

SOUTH PLATTE DIVISION, No. 1.

No. of water district.	Name of principal stream in district.	Ditches.	Under ditches.	Actually irrigated.
		Miles.	*Acres.*	*Acres.*
1 6	South Platte	238.00	150,000	39,719
2	....do	150.00	174,000	46,233
3	Cache le Poudre	340.75	207,360	103,895
4	Big Thompson	236.66	80,690	69,908
5	St. Vrain	225.50	92,460	86,655
6	Bowlder Creek	125.00	89,580	72,895
7	Clear Creek	240.00	98,558	66,405
8	South Platte	206.50	131,537	53,110
9	Bear Creek	50.00	6,915	3,742
23	South Platte	61.50	23,270	20,920
47	North Platte	124.00	46,980	41,080
46	....do	61.45	24,330	21,470
48	....do	8.00	800	4
	Total	2,067.36	1,126,800	631,036

ARKANSAS DIVISION No. 2.

10	Fountaine que Bouille	53.00	32,686	18,000
11	Arkansas	46.10	39,820	34,780
12	....do	34.00	33,760	25,520
13	Grape Creek	3.00	600	549
14	Arkansas	92.50	13,694	7,265
15	St. Charles	91.50	7,314	4,543
16	Huerfano	340.00	32,129	12,547
17	Arkansas	167.50	224,640	38,700
18	Apishapa	24.00	6,700	6,000
19	Purgatoire	58.10	33,380	25,660
49 66 67	Various	29.70	5,490	2,492
	Total	943.30	440,240	116,047

RIO GRANDE DIVISION, No. 3 (SAN LUIS VALLEY).*

20	Rio Grande	300.00	398,140	98,515
21	Alamosa	175.00	57,711	45,093
22	Conejos	160.00	45,711	33,340
24	Culebra and Costilla	(†)	(†)	(†)
25	San Luis Creek	227.78	42,425	31,315
26	Saguache	143.80	33,380	28,000
27	La Garita	5.60	570	500
35	Trinchera	21.50	18,160	13,500
	Total	1,033.68	596,097	250,263

* The records relating to this division are not complete. † No data.

RECAPITULATION.

Division No. 1	2,067.36	1,126,800	631,036
Division No. 2	943.30	440,240	116,047
Division No. 3	1,033.63	596,097	250,263
Aggregate	4,044.29	2,163,137	997,346

Total area of arid land, 30,000,000 acres.

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Colorado (eastern slope).—Tabulated summary of reservoirs so far as the same are of record in the office of the State engineer.

DIVISION No. 1.

District.	No. of reservoirs.	Area.	Capacity.
		Acres.	*Cubic feet.*
First	10	.....	27,419,536
Second	8	.....	538,787,000
Third	5	.....	188,994,950
Fourth	1	.....	180,000,000
Fifth	2	.....	165,164,080
Seventh	21	.....	1,114,089,456
Eighth	14	.....	1,688,381,817
Ninth	13	.....	263,778,940
Twenty-third	1	.....	2,214,323
Total	75	.....	3,168,780,082

NOTE.—The above number of cubic feet of water would furnish 1 foot in depth for 72,746 acres.

DIVISION No. 2.

Tenth	29	.....	115,937,752
Eleventh	3	.....	20,613,408
Fourteenth	17	.....	1,011,596,143
Sixteenth	8	.....	98,329,398
Seventeenth	20	.....	823,524,005
Total	77	.....	2,069,000,706

NOTE.—The above amount would furnish 1 foot in depth of water for 47,495 acres.

DIVISION No. 3.

Twenty-second	4	.....	16,000,000
Twenty-fifth	2	.....	66,000,000
Twenty-sixth	1	.....	50,000
Twenty-seventh	3	.....	109,000
Total	10	.....	82,159,000

NOTE.—The above amount would furnish 1 foot in depth for 1,885 acres.

GENERAL RECAPITULATION.

Division.	No. of reservoirs.	Area.	Capacity.
		Acres.	*Cubic feet.*
First	75	.....	3,168,780,082
Second	77	.....	2,069,000,706
Third	10	.....	82,159,000
Grand aggregate	162	.....	5,319,939,788

NOTE.—This total amount of water would furnish 1 foot in depth of water for 122,129 acres.

ITS AGRICULTURAL PRODUCTIVENESS.

Colorado is especially adapted to the production of the grains, grasses, and roots of the temperate zone. The eastern foot-hills are found valuable for the fruits thereof, while in the valleys of the western slopes the finer fruits, such as grapes, apricots, etc., can be profitably raised. In the San Juan, to the southwest, the semi-tropical

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fruits and crops will be cultivated successfully on the mesa and valley lands.

Of the area of Colorado, 98.2 per cent. is not in farms. Of tillable land the area is 23.8 per cent.; grass land, 29; woodland, 3.8; and the unproductive is rated at 43.4 per cent. Colorado stands as to productivity as follows:

	Bushels per acre.	Average.
Corn	27.7	24.2
Wheat	19.6	12.3
Oats	31.7	27.0

From 1884 to 1889, the public domain lying within the borders of Colorado has been occupied to the total of 9,155,561 acres. This is within less than 1,000,000 acres of the total amount of arable land which, in 1880, the public lands commission declared was the whole arable area left for settlement. It is evident that the specialists do not know all the facts or are able to accurately forecast the future.

ONE OF ITS LARGE IRRIGATED AREAS.

In the San Luis Valley there is 468 miles of ditch. One canal, known as the Rio Grande Canal, is the largest in operation at present in the West. There is 312 miles of ditch system. The canal at the head is 80 feet wide on the bottom, and will finally supply water to about 240,000 acres of land. The conditions and character of the soil of the San Luis Valley, on the Rio Grande River, in the southern part of the State, are different from other sections of Colorado. That valley has an area of 5,000 square miles, and probably 3,000,000 acres could be redeemed if the water is there to do it with. Altogether, in the San Luis Valley, there are above it 1,150 or 1,200 miles of canal, supplying about 1,500,000 acres of land. The water supply is not sufficient to irrigate those lands at all times.

The Rio Grande River carries a large amount of flood water during the summer months. There are probably six weeks during the average year when there will be sufficient water to irrigate the entire valley if it could be relied upon. There are fine sites within the mountains adjacent to the valley for building reservoirs.

In order to redeem that entire area it is necessary to conserve the water. With that area 150,000 or 200,000 people can be supported, but with the present irrigating facilities and water supply not more than 50,000 people. The soil is good. The altitude is about 7,500 feet, but the latitude is such that it gives a good locality for irrigation. The San Luis Valley, the largest valley in the Rocky Mountain region, has a soil somewhat peculiar and different from the soil on the eastern slope of the mountains. It is underlaid by a heavy stratum of drift.

Artesian water is found in the San Luis Valley at a depth of 800 feet, a very full flow of water that will cut a figure sometime in the progress of irrigation; but even with such artesian and all the surface water, the valley will not be reclaimed without storage.

Most of San Luis Valley is still public land, but the State has some 200,000 or 250,000 acres therein. In order to induce capital to vinest, the State has passed a law providing for the sale of the State land in alternate quarter sections at $1.25 per acre to any company

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that would build a canal large enough to supply the entire area. They require the canal company to make a contract and give a bond and supply that land. Capital is not, however, ready to go in and investigate and make the expensive examination necessary to ascertain whether such canals are feasible. There are a number of canal and other irrigating projects, especially in the western and southwestern portions of the State, that would be undertaken if it could be demonstrated they were feasable, but in order to demonstrate that it would require the expenditure of considerable money.

If the information could be got and promulgated, showing that these schemes are feasible, capital might be induced to go in and construct them. That is especially true in Grand Valley. This valley, extending from Grand Junction over to the valley of the Green, in Utah, embraces a fine section of land, but to build a canal that would reclaim the whole of the land that is irrigable therein would require much money. Reconnaissances have been made to ascertain that, and it was ascertained that the canal would cost probably $2,500,000.

THE HISTORY OF GREELEY AND THE FIRST IRRIGATION COLONY.

Union colony is situated in Weld County, State of Colorado. It was located in the spring of 1870, and the town of Greeley was laid out and building and other improvements commenced at the same time. The town is located in sections 5, 6, 7, and 8, township 5 north, range 65 west of the sixth principal meridian; latitude 40° 25′ north, longitude 27° 48′ west from Washington; elevation above sea-level, 4,800 feet. At the time the colony and town were located the whole country was, with few exceptions, in its natural state, no improvements having been made except in a small way along the river. A few small irrigating ditches had been built to water portions of the low bottom-lands, and sufficient farming had been done by the early settlers to demonstrate the fact that good crops of all kinds usually grown in this latitude could be raised successfully.

The mesas or uplands were regarded as worthless for farming purposes, and only valuable for grazing, many of the best informed expressing the opinion that large and long irrigating canals to water the higher lands would be a failure. In support of this view it was said that the water would seep out and be lost before running in a canal any great distance, and that the land would be quickly exhausted if farmed, and various other reasons why upland farming would be liable to prove unsuccessful were pointed out.

Notwithstanding all the uncertainties that must be encountered, the projectors of "The Union Colony of Colorado," located in the Cache la Poudre Valley, purchased the land they required from private owners, and the Denver Pacific Railway Company homesteaded and pre-empted Government land, laid out the town, and proceeded to build irrigating canals to water the same. About 2,600 acres of land was bought of private owners for $28,000 and 9,300 acres of the railway company for $31,000.

The colonists contracted with the railway company for all the land owned by them lying within the colony limits at an average price of $3 per acre. The Government land was acquired by the colonists under the homestead and pre-emption laws. The total amount of land originally occupied by the colony was about 30,000 acres, and remains about the same. Soon after locating the colony built a fence some 40 miles in length, inclosing all their lands, including the town. This fence is

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still maintained, having been legalized by an act of the State legislature and being managed by a fence company. Each piece or parcel of land pays an annual tax for its maintenance, the annual assessment being about $16 for each 80 acres, and in like proportion for larger or smaller tracts. No stock of any kind is allowed to run at large inside of this fence, and none have found it necessary to fence their premises, either in town or outside, except for their own convenience. The colony originally divided the land owned by them outside of the town limits into lots of 5, 10, 20, and 40 acres each, according to their proximity to town, and deeded them to members, with perpetual right to water from the irrigating canals, for $150 each.

Other members bought land of the railway company for $3 per acre or homesteaded or pre-empted Government land. To these the colony sold right to water in perpetuity for $160 for each 80 acres. All water rights are taxed annually a sufficient amount to pay for superintendence, maintenance, and improvement of the main canals, generally from $12 to $24 annually for each 80 acres and in proportion for smaller subdivisions. Few of the colony farmers have more than 160 acres; generally they have 80, and in some cases as low as 40 or even 20.

The land occupied by the town, some 800 acres, originally cost the colony about $10 per acre, or $8,000. It was subdivided into about fifteen hundred lots of suitable size and sold to members at an average price of about $300 for each ($50 for corner and $25 for inside lots), making about $45,000 as the amount received by the colony for lots. The cash value of such lots was lawfully $300 each, making $450,000. The outside or farming land originally cost members about $5 per acre with water, and is worth $30 per acre cash, with actual sales at $35 and over for land with no improvements except plowing and ditches, including water right, the colony having long since sold all the land and water owned by them and transferred all their right in the main canal used by the farmers to a corporation composed of farmers operating under it. This company issued its stock to the water-right owners on receiving a deed for their interest, each share of stock representing water for 10 acres. In 1878, when this transfer was made, the par value was $40 for each share, making the value of an 80-acre water right $320. In 1881 the price rose to $100 per share, and it now sells at $100 to $125. This stock has actually cost the original owners about its par value, $40 per share. When land is sold including water, the stock is transferred. Nearly all the larger canals are now owned and managed by corporations who have power to levy and compel payments of assessments and divide the water equitably among the users, thus preventing nearly all the trouble which formerly attended the management of the earlier canals. The water costs the farmer the same whether he is situated near the head or at the terminus of the canals, and the same principle has been adopted in the management of the sub-ditches or laterals, as it has been found that no canal from which a number of individuals receive their water can be successfully operated without a competent head.

Union Colony constructed two irrigating canals and one for power and irrigation. The first canal built was for the purpose of supplying the town and adjacent lands lying along the south side of the river. This is called canal No. 3. This canal was taken from the river about 6 miles west of town, and was run on a grade or fall of about 3 feet per mile. Its original size was 8 feet in width at head, and somewhat smaller opposite town. Its length is 10 miles. It terminates on the delta between the Platte and Cache la Poudre Rivers. As originally

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constructed it would carry about 50 cubic feet of water per second. Original cost about $10,000. It has since been enlarged and improved, its present capacity being over 100 cubic feet per second. Cost to present time, including dam at head, about $25,000.

The second canal built by the colony was taken out the river, about 15 miles west of town, for the purpose of watering the farming lands north of the river. As originally constructed it was 10 feet in width on the bottom at the head and for the first 5 miles, and gradually diminished in size towards its terminus, its total length being 26 miles. Grade or fall, 3.2 feet per mile; capacity, 110 cubic feet per second. It was calculated to water some 20,000 acres of land. Its first cost was $25,000; has been enlarged from time to time, its capacity now being 585 cubic feet per second. It will furnish water for 25,000 acres in cultivation, with the usual variety of crops. Cost to date, $80,000, or about $3 per acre for land watered by it. It is now 25 feet in width on bottom at head, and for the first 10 miles carries water 4.6 feet in depth, and is 30 miles in length. The number of water rights of 80 acres each is 320, giving over 1.8 cubic feet of water per second for each 80 acres, less about 10 per cent. for evaporation and seepage, or about 1.6 cubic feet per second for useful effect. As new land in wheat requires about 1 cubic foot of water for each square foot of surface for first watering, it would take over twenty-five days to water 80 acres with one water right, but generally only a portion of the tract is sown or planted the first year and less water is required after the first thorough irrigation.

Very much depends on the surface quality of soil and subsoil and amount of natural moisture in the ground, so that no very definite information can be given as to the amount of water necessary to irrigate a certain piece of ground. The usual experience is that a cubic foot of water per second waters from 50 to 60 acres of land sown or planted with the usual variety of crops. In town more than double that quantity of water is used, as the more a stream of water is divided up the less ground it will water. The farmers find it to their advantage to use two or three water rights when irrigating a favorable piece of ground by changing with their neighbors. The Cache la Poudre River, from which the colony ditches are taken, generally furnishes enough water when most is needed. There is generally sufficient snow or rain to start crops in the spring and keep wheat and oats growing until the 1st of June.

During June and July the maximum quantity of water is flowing in the river, and it is during these months that most of the crops must be watered. The amount of water flowing in the river each day is ascertained at a gauging station located above all the canals, and the amount or proportion of the water to which each is entitled being known, the district commissioner or superintendent is enabled to divide the water equitably to all. The river or district commissioner is not usually called on unless there is a short supply of water, which usually occurs in the latter portion of the season. The water commissioner on each canal divides the water to each subditch or lateral, and the users divide it among themselves. Since the present State laws regulating the division and distribution of water were enacted and put in force very little trouble has arisen in regard to the use of water for irrigation purposes.

The maximum amount of water flowing in the river each year is very variable, ranging from less than 2,000 to over 6,000 cubic feet per second. As the canals taken from the river have a capacity and use for over 3,000 cubic feet per second, it will readily be seen that there is

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an element of uncertainty as to water supply and the future extension of the irrigation system. Water has already been appropriated and canals built sufficient to water over 200,000 acres in this valley, and it is not probable that this amount will be very materially increased. The total amount of water flowing in the river during the year would water more than double this quantity of land, but it can only be utilized by a system of storage reservoirs. Comparatively little has as yet been done in the way of storing water in the State, and it is not probable that much will be done for many years to come. Some natural depressions or basins of moderate capacity are used for this purpose where they chance to be available, but no purely artificial reservoirs worth mentioning have as yet been constructed.

The great expense of building and maintaining large reservoirs makes it extremely improbable that our water system will be much extended in this way. Reservoirs to be of any use must be situated above the land to be watered, and where constructed in this vicinity on a small scale the land lying adjacent to them has generally been spoiled by the seepage. The parties owning land which is damaged by such seepage usually compel the owners of the reservoirs to stop using them for storing water. The influence of irrigation on the humidity of the atmosphere is very slight, being almost entirely local, and on new lands, outside of the irrigating canals, farming would be as certain to prove a failure as it would twenty years ago.

If any climatic change ever occurs in this locality whereby the humidity and annual precipitation is permanently increased, it will not be due to the feeble efforts of man. The annual precipitation about Greeley is from 12 to 20 inches, the average being 15 inches for the last twelve years, as observed in Denver. The destruction of the timber in the western mountains must injuriously affect the water supply during the irrigating season by leaving the snow exposed to the direct rays of the sun, causing it to melt quickly and run off. The advance of the farmers from the East with a solid front, plowing up the entire surface, may produce some change. If the annual rain-fall was double what it now is, farming could not be carried on successfully, except in favored localities, the evaporation being so rapid during the growing season. In Greeley, situated on what is called the second bench or bottom, some 25 feet above the level of the river opposite, gardens and lawns must generally be watered every week or ten days in dry weather, and the farmers do not stop irrigating on account of an occasional shower. Much as such increase of natural moisture may be desired, there is no good reasons for expecting it, though there is a reasonable certainty of producing a more equalizing distribution of local rain fall, through the effects of cultivation on the humidity of the soil, and by the influence of wind-breaks and other tree plantations in destroying the desicating effects of the hot winds.

Although this town and surrounding country has been irrigated for many years, raising the ground water, in portions of both town and country, nearly to the surface, causing it to partially fill many of the cellars under dwelling houses, no malarial diseases have been prevalent. The surface soil is generally a clay or sandy loam, from 5 to 10 feet in depth, underlaid with clear sand or coarse gravel 25 to 30 feet in depth, which affords a good natural medium for the rapid transmission of surface water to lower levels, but within the last few years more water has been run on the surface in town than the natural drainage will carry away; and we are now constructing deep drains to prevent the water from rising above a certain level. Said drains are located from 8 to 10

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feet below the surface and have a good fall to the river. Our farmers do not keep much stock, as they do now, as formerly, have outside range for them. Alfalfa is grown by nearly all our farmers and yields heavily. It is usually cut three times, giving from 4 to 7 tons per acre annually.

The usual variety of crops is raised, wheat, corn, oats, and potatoes being the principal ones. Wheat is still the main crop, and the quality and yield are generally good. It produces on an average over 25 bushels per acre, when properly put in and attended to. Average of all sown, about 20 bushels. Corn is quite extensively grown, and yields from 20 to 40 bushels per acre; oats about the same, and potatoes from none to 100 bushels per acre, much depending on soil, season, watering at proper time, blight, bugs, etc. In town and vicinity market gardening is successfully carried on. Of fruits, strawberries and raspberries are the ones mostly grown for profit. Standard apples are a failure, but most varieties of crabs do well. It would be difficult to give the aggregate amount and value of all crops raised in this colony without having the report of the State census, taken last year, which is not now available. Nearly all the land in the colony has been farmed continuously for the last ten years, and much of it longer, but its fertility does not seem to decrease.

Crops, when properly rotated, do as well now as when the land was first broken. Scarcely any fertilizers are used on the farming land, and straw is usually burned to get it out of the way. The water used in irrigating the land carries a great amount of fertilizing matter, which is evenly distributed over the surface, fully replacing what is taken from the soil by the crops grown on it; and it is the general opinion of those most conversant with the subject that the soil is practically inexhaustible.

THE IMPORTANCE OF SMALL FARMS.

Thomas P. Dunbar and J. R. Burton, witnesses before the Senate Committee on Irrigaton, stated as to small farms:

That they produce a better class of crops, fruit, vegetables, hops, and so on. There is a large demand for hops. I know a man making $300 or $400 an acre on hops, and a man can easily make $100 an acre on alfalfa. To get the best results a man must have a small area and cultivate closely and have a supply of farm-yard manure. Our soil here is very heavily charged with mineral matter and is very deficient in manure material. He must grow a variety of crops. We do not want men to raise a large surplus, but we want large communities and to have the land more closely cultivated, so as to bring our population nearer together, and have them produce everything that men can and need to live upon. That is what brings wealth into any State. All our immigration comes from non-irrigated districts. Everything here is new to such immigrants. The conviction is forced on my mind that a man is better off with 40 acres thoroughly cultivated than 160 acres half cultivated. You can not convince the immigrant of it, however.

My observation is that a man is better off with 40 acres in the arid belt with every foot of it well cultivated, and his crop thoroughly attended to, than he is to have 160 acres skimped over. The man with 40 acres in the arid belt, well cultivated, will make more clear money in the end. I will lend him 25 per cent. more money on 40 acres of well cultivated land than on 160 acres half cultivated. The men that have a section of land have to have machinery and all that. Then a man's water-right will go farther on a small farm. His supply of water would have to be all put on at the same time. One great thing is to protect the land from the rays of the sun to prevent baking. You can not do that with a very large farm. I have often gone into an alfalfa field where the alfalfa grows half an inch a day in the warm weather, and within two or three weeks after it had been irrigated the crop was up 6 inches, which would prevent the land from being dried up. I have picked up there as damp a piece of soil as was wanted. On the other hand, I have been in a wet field that had been irrigated a few days before, when there was nothing to protect it from the rays of the sun, and the soil was baked hard.

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With regard to the homestead law, I believe a man should not be allowed to pre-empt more than 40 acres of land in the arid region. I believe the homestead law ought to be amended so that one person could not acquire more than 40 acres of land under its provisions in the arid region. My reasons for this position are, first, the average farmer could make more money farming 40 acres of land by irrigation than he can a larger amount. The homesteader is a poor man, generally. He must borrow the money, at a very high rate of interest, with which to improve his land and live upon it, to provide himself with the necessary farming implements. He must go in debt for water, and wait for the harvest season for any returns from his toil and expenses. If he has 160 acres, his great desire to improve it all causes him to buy too much water, too much farming machinery—in short, it causes him to shoulder too much debt. His taxes and expenses are greater, and he is not capacitated to farm so much land, and farm it well, and the result is his harvest is no greater than it would have been had he carefully cultivated a smaller tract. Instead of getting out of debt and saving a little spare money to invest in live-stock, or to help develop some other industry in his immediate locality, at the end of ten years he is above the average farmer if his quarter section is not mortgaged and a large share of his earnings does not annually go to the money-loaner.

Then, again, it is far better for the ditch company for the farmers to have small holdings of lands. They are enabled to pay out on their water-rights, or to keep up the water-rentals. But a still greater reason is that, if the homesteader could not secure but 40 acres of land, the opportunity for speculators to secure the land in the arid region by engaging professional homesteaders to prove up and obtain title would be greatly lessened. There are localities where ditches or reservoirs could and would be built but for the fact that speculators have obtained the land in this way. The interest of the ditch company and the land-owner ought to be mutual. Where the land is held by farmers for homes, and especially where the land is cultivated, it is so, and there is but little or no friction between the owners of water and the owners of land.

I also think the law ought to be changed, so as to make the cultivation of the land for a given time requisite to obtain title, rather than occupancy. Land that is cultivated in the arid region must have water. If the farm is once put into a state of cultivation and has a water-right attachment there is no danger but that it will be occupied and forever after be a home for somebody. But under the law as it now is a homesteader may put upon the land a trifling building, ever so small and worthless, sleep there occasionally, but in reality live elsewhere, and in a short time have title from the Government, called a homestead, which in reality remains wild land. The spirit of the homestead law is violated, there is no home upon the land; it is used entirely for speculative purposes. I am not stating an exceptional case. In many localities it has been and now is the rule to obtain what is miscalled a homestead in this way.

THE WATER-LAW SYSTEM OF THE STATE.

Colorado, through its courts as well as legislation, was the first State to recognize the miner's law of prior appropriation of water as applicable, with restraining interpretation, to beneficial use in agriculture. The State has recognized as fundamental the principle of the public nature and property of all natural waters lying within a region so arid that agriculture can not be carried on without the artificial conservation and distribution of the same. It has applied two qualifying interpretations to the doctrine of prior appropriation. One is, that the beneficial use, which is the basis of such appropriation of water, must necessarily be limited in its application by the wants of all other subsequent users; that is to say, that an appropriation made in days when necessity was unknown could not be construed to deprive the members of a growing community of their pro rata share after the first or prior appropriator had received his portion. The other is, that water being public property, the carriers of the same by means of ditches or other methods can claim no ownership or possession in the water itself. Their remuneration is derived from the transportation and distribution through the channels they construct to the lands on which it is needed.

Colorado has also declared that water companies are common carriers, and their legal status to be the same as that of railroads or other transportation corporations. The State, following these lines,

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early assumed a direct supervision over the whole subject. Its area is divided into six irrigation divisions which are again subdivided into sixty-eight water districts, each one of these representing in the main a distinct drainage or irrigable basin or region, deriving its supply from some common source. The State supreme court announced this doctrine before it was incorporated into the statutes, declaring it to be the common law doctrine for their conditions. Such a decision requires two acts to make it valid; that is, the diversion and use of water for a beneficial purpose.

The statutes of Colorado, therefore, divide the State into irrigation districts. Under these statutes the district courts, which are the highest courts of record next to the supreme court, adjudicate what we call the priorities of right. These districts are generally arranged with reference to the natural streams, and if from the principal natural stream in a district one hundred ditches have been taken, the court proceeds in the method pointed out by statute to determine the dates at which each of these appropriations were made when the ditches were constructed; the size of the ditches; their capacity; the degree of fall of the water. Then a decree is entered which declares these dates, declares these facts, and assigns the priorities to these ditches in accordance with the dates of the diversion. Under these views the use must follow the diversion within a reasonable time. The decrees assign to these ditch priorities in accordance with the dates of the diversion. The use is thus connected with that diversion. The question of reasonable time goes according to circumstances. If the ditch is dug with due diligence and the water is applied reasonably soon the priority relates back to the date of the commencement of the ditch. It must remain a question of fact to be determined at each particular case. This decree also determines the quantity going to each ditch. The decree of a given district must be considered, and the quantity of water assigned to each particular ditch or to all the ditches taken together in the aggregate would constitute the quantity in use or the quantity assigned. If there is not water enough, those having priority under the decree would get it first. In each district there is an irrigation commissioner whose duty it is to superintend the distribution of water according to the decrees of the court. The governor appoints a commissioner for each water district.

FARMERS' WATER SERVICE AND "RIGHTS."

The organization of the water-carrying companies is divided into two classes. The mutual companies generally divide the ditch into shares—each person taking a number of shares—depending upon the extent of his property underneath. The amount of water he gets from the ditch depends in that case upon the number of shares he has in the ditch. It is divided according to the number of shares. The stock companies generally sell the water, or water rights. "Water rights" is generally taken to mean the supply of water necessary for 80 acres of land. In such companies they agree, if they have water, to give a definite amount of water, not exceeding a certain quantity. There are two general types of contract; first, a contract made by the company with a man to sell him a certain amount of water on certain conditions, provided he keeps up his payments. The second is a water deed, which is given to the man in exchange for the first, when he has carried out the provisions of the first contract. These contracts represent the provisions of nearly all companies.

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In most cases farmers have a perpetual water right. Under a few canals they rent water. The prices for perpetual water rights vary with the different canals. In the San Luis Valley they pay $400—that is, $5 an acre for the perpetual right. In the northern part of the State the Larimer and Weld Company have a different price. In the case of the North Poudre it is $15 an acre. The North Poudre also has a charge of $1,200 for a perpetual right. Another prevailing price is $800, and another one is for $1,000. The Arkansas Valley Company charges that much. That is for a perpetual water right, but all subject to an assessment for maintenance. The farmers are assessed for running expenses. Very frequently there is a provision that an assessment for maintenance shall not exceed a certain amount, say $10 for 80 acres, for ordinary assessments. Then there is a provision that in case of a very extraordinary difficulty in that ditch, or extraordinary repairs, they may be subject to a certain maximum assessment, $20 or so. The ditch company is the judge. An extraordinary assessment is rarely charged, even when there are extraordinary difficulties. In smaller ditches the assessment is more, depending somewhat upon the local conditions or the difficulties the company think they may meet. In the case of union ditches, the associates keep the ditches in repair, and the prices are less, because generally the ditches are smaller and the expense of maintenance is less. A small ditch runs itself almost. In the small ones it is perhaps from 5 to 15 cents per acre per year for maintenance. Each large ditch has a superintendent, whose business it is to distribute the water. The stock owners appoint, or in the case of a mutual company, they have a meeting, as every company would have, and make their own arrangements. The superintendent is an officer of the company, and he distributes the water according to the farmer's holdings in the ditch. In the smaller ditches, where they have plenty of water, each man takes all the water he wants.

Colorado has hardly grasped the idea embraced by the district system now being organized in California. To meet the evils and inequities which have grown up in the State as elsewhere under the corporation system, an agitation has sprung into existence, on the part of the combined farmers, which makes a demand for State possession and ownership of all water ditches and their laterals. The State being a large owner of land has already found it advisable to construct ditches in certain localities in order to make its lands valuable.

THE IRRIGATION CAPACITY OF NEVADA.

The area of this State is 71,737,600 acres, of which the water area is but 1,081,600 acres. The timber is estimated to cover 2,600,000 acres; the pastural area is estimated to be 30,000,000 acres, the mineral area 15,000,000 acres; the desert and saline deposit, 3,656,000 acres, and the agricultural area is placed at 20,000,000 acres. That is the area to be reclaimed, if water can be obtained.

The State board of reclamation, appointed to consider the question of irrigation therein, in the report embodied in your testimony, presents a series of statements by counties, which will show an area of 17,981,000 acres as possible for reclamation, of which area 2,198,000 acres can, in their judgment, be reclaimed by wells and springs that are known to exist. In Esmeralda County, in the southwest, there is an area considered to be reclaimable, and also in White Pine and in Nye County, in the southern and eastern part of the State. There are sixty-five ar-

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tesian wells in Nevada. The average altitude of the State is considerably over 4,000 feet above the sea-level. It is a mountain bowl surrounded by high ranges, and the fact that there is found even that limited number of artesian wells would indicate the necessity at least of examining into the character of the drainage or under-ground water supplies. There are a large number of important springs.

The trouble with Nevada is, in the main, that the drainage area that will most surely supply the water needed for reclamation is found largely within the limits of other States and Territories. In the north, the rivers head up in the northerly and northwesterly Territories. On the west, the easterly slopes of the Sierras are unquestionably part of the drainage area of Nevada. The great lakes that lie upon the Sierra Nevada are mainly upon the eastern slope of those mountains, and the waters naturally and properly belong to the people of Nevada. Take Lake Tahoe, 78 square miles of its surface (that is, two-fifths) are within the lines of the State of Nevada; the remainder is within the lines of the State of California. Lake Tahoe is ranked with navigable waters and belongs, then, to the Federal Government. It is all on the eastern side of the mountain. The ranges rise from 3,000 to 6,000 feet above it. Lake Tahoe has a drainage area of at least 1,200 square miles; the valley of the Truckee has a large drainage area. From Lake Donner, and the other lakes that are known along that range, water can be obtained. Lake Donner has been surveyed and its boundaries meandered. It is now reserved for irrigation purposes. Sufficient water can be obtained for western Nevada without the loss of a single cubic inch to California. By the storage of water in the mountain lakes alone, enough can be obtained to reclaim from 1,000,000 to 3,000,000 acres of land. Even if it be but 1,000,000 acres it will amply repay all its cost and double at once the values of the State.*

That land is worth nothing, or very little more than nothing, now. It would be worth from $15 to $30 an acre if it were watered. That would make as prosperous a community as could be formed within the borders of the Union. Nevada was born during the war, and by her mines hundreds of millions in precious metals have been added to the general wealth of the country. The larger proportion of those who have benefited by that development have left Nevada to struggle through the poverty and indifference that are now surrounding her people. There are now some 300,000 acres under fence and ditch, about 75,000 being cultivated.

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* To the 16 inches stored above the 6,000-foot elevation should be added that which, falling below the 6,000-foot, melts and runs down in the spring and early summer. The average depth of this snow is about 5½ feet, and I estimate its quantity of water from my average found for snow freshly fallen, viz, 1 inch of water to 11 inches of snow. * * * It can be safely estimated that 9,000 square miles of mountainous surface will catch this amount of snow in average winters, thus giving 6 inches of water; this added to the amount falling upon the higher altitudes gives 22 inches of water, the greater part of which can be, by careful planning, made available for irrigation purposes.

There is not less than 4,800 square miles of the Sierra Nevada Mountains which shed water into Nevada. Of this area 250 square miles store annually 14 inches of water; 560 square miles store annually 19 inches of water; 1,330 square miles store annually 36 inches of water. All of which that is not lost by evaporation and percolation comes down into Nevada, giving rise to the Truckee, Carson and Walker Rivers.

I estimate the agricultural lands of Nevada at 21,000 square miles. This area will, I believe, be increased in the future by the addition of many square miles of foot-hills now classed as mountains. Be that as it may, the water supply of Nevada, as I have outlined, is sufficient to furnish each square mile of agricultural land in the State with 42 inches of water per annum.—*U. S. Surveyor-General Irish.*

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IRRIGATION CONSTRUCTION IN WYOMING.

Territorial Engineer Mead reported to the Senate Committee on Irrigation the following tabular statement:

Irrigation development by districts.

District.	Total No. of recorded ditches.	Total length as stated.	No. of claims, with statement of length omitted.	Total capacity as given.	No. of ditch claims, omitting statement of capacity.	Total acreage watered as given.	No. of ditch claims, omitting statement of acreage.
1*	643	1,322.385	39	5,911.584	48	482,434.00	89
2	327	582.793	31	6,649.844	53	379,174.64	62
3	282	317.419	91	3,644.078	72	395,563.00	114
4†							
5	502	996.398	32	10,422.700	57	440,540.00	50
6	124	196.955	46	1,556.325	36	58,162.00	55
7	322	518.240	50	1,658.905	96	108,976.78	95
8	182	212.510	52	3,095.487	79	35,395.00	96
9	49	91.430	1	342.000	25	42,460.00	3
‡	7	11.905	.....	136.800	.....	4,180.00	.....
Total...	2,438	4,249.935	242	20,381.723	466	1,946,875.42	564

*Seven reservoirs additional.
† District No. 4 omitted because of incomplete record.
‡ Unorganized district.

Of this area of nearly 2,000,000 acres not more than 80,000 acres are under cultivation other than for stock purposes.

The best agricultural portion of Wyoming is the northeastern. Only a few years ago agriculture in Johnson County was not considered an industry worthy of consideration. This was the fact in 1881, as the following figures of assessed valuation for that year show:

Cattle in 1881	$1,047,688
Lands in 1881	34,485

The great distance from railroads and the demand for vegetables and grain for home consumption forced the people to experiment with crops. The result was startling, and the sequel was that the business of farming became a leading industry within the next five years. Land "proved up" is assessed for taxation at a value of $3 per acre, including improvements. It is easily worth an average of $10 per acre. The following table of values from the assessment roll of lands shows the increase from 1881 to 1887 in farming lands:

1881	$34,485	1885	$166,032
1882	51,195	1886	229,644
1883	66,160	1887	485,439
1884	147,785		

The real taxable value of this taxable land is at least three times this amount, or in 1887 $1,456,317, which is $408,649 more than the value of the cattle in 1881.

But one-fifth of the lands susceptible of irrigation have been artificially watered. The total area of irrigable lands is estimated at 953,000 acres, and at an average value of $10 an acre would be worth $9,530,000. Its elevation is only about 4,000 feet. Its streams are more frequent and available than any other portion of the Territory. It is also one of the best watered counties in Wyoming, being well supplied with innumerable streams heading in the Big Horn Mountains and flowing generally to the northeast and northwest. The water along the

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foot-hills is clear, cold, sparkling, and soft. The soil is black and sandy loam, and appears to be capable of producing wonderful crops, with irrigation, of anything that is planted in it.

The agricultural products of the county are wheat, oats, barley, corn, rye, hay, potatoes, vegetables, and fruits. The yields are: Wheat, 20 to 50 bushels per acre; oats, 25 to 75 bushels per acre; barley, 40 to 75 bushels per acre; rye, 20 to 40 bushels per acre; potatoes, 200 to 500 bushels per acre; hay, native blue stem, 1 to 2½ tons per acre; timothy, 2 to 3 tons per acre; alfalfa (lucern), 4 to 6 tons per acre.

As to the future: If one-third of the irrigated lands of this county were sown in wheat, at an average of 30 bushels per acre, it would yield 2,340,000 bushels or 130,400,000 pounds, equal to 7,244 car-loads. If one-third of the area was sown to alfalfa it would produce 192,000 tons annually, and would fatten 58,400 steers, equal to 2,900 car-loads. Not more than one-fifth of the lands susceptible of irrigation have been watered. The possibilities that may be attained when development is complete become enormous.

AGRICULTURE IN THE DAKOTAS.

The year 1889 was one of exceptional drought.* Even so, the Dakotas presented in crops the following results:

	North Dakota.		South Dakota.	
	Acres.	Bushels.	Acres.	Bushels.
Wheat	2,655,991	26,721,660	2,013,726	17,288,432
Oats	450,563	9,746,093	671,839	11,623,615
Corn	30,022	1,000,175	784,655	21,831,898
Barley	3,167	45,487	127,338	1,694,875
Buckwheat	205	2,897	2,828	29,667
Potatoes	16,119	1,401,130	29,537	2,637,132
Flax	57,511	495,202	345,803	2,792,913
Rye	.....	.....	16,587	255,620

Statement showing monthly, annual, and average precipitation, in inches, as recorded at the U. S. Signal Office, Huron, Dak.

Month.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	Total by months since station opened.	Averages by months.
January	.....	0.14	0.17	0.09	0.15	0.48	0.33	0.78	1.26	3.40	0.425
February	.....	0.25	0.47	0.58	0.22	0.16	1.11	0.52	0.93	4.24	0.530
March	.....	0.80	0.42	1.53	0.12	0.62	0.64	1.22	0.19	5.54	0.692
April	.....	4.18	2.14	2.70	1.06	3.52	3.72	0.88	3.41	21.61	2.700
May	.....	4.50	4.45	2.90	5.20	1.58	1.39	4.98	3.04	28.04	3.505
June	.....	5.86	4.33	3.18	5.43	1.90	3.98	1.10	1.04	26.82	3.352
July	†3.58	5.88	5.20	5.11	4.52	1.60	4.96	3.11	3.51	37.47	4.163
August	6.31	1.44	1.77	1.18	3.89	5.62	6.13	3.46	.....	29.80	3.725
September	3.11	0.86	1.68	1.26	2.61	1.59	0.15	0.19	.....	11.45	1.432
October	2.10	3.37	1.96	1.52	0.98	1.26	0.79	0.29	.....	12.27	1.534
November	0.45	0.61	0.05	0.17	1.50	1.18	0.25	0.34	.....	4.55	0.569
December	0.06	0.23	0.61	0.62	0.10	0.74	2.09	0.18	.....	4.63	0.579
Total	15.61	28.12	23.25	20.84	25.78	20.25	25.54	17.05	13.38	.....	.....

Total inches for seven complete years, 160.83. Average for seven complete years, 22.98.

†Station opened July 1, 1881.

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Average monthly and annual precipitation (rain-fall and melted snow) in the two Dakotas for the periods and localities named below.

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual precipitation for each locality.	Period covered by reports (dates inclusive).
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	
Fort Abercrombie	0.50	0.09	0.63	1.70	1.80	1.73	1.79	2.18	1.85	0.37	0.60	0.52	13.76	July, 1874, to Oct., 1877. Record of post surgeon (incomplete).
Fort A. Lincoln	0.44	0.64	0.84	2.30	2.45	2.96	1.75	2.14	0.80	1.04	0.49	0.79	16.95	July, 1874, to date. Record of post surgeon.
Alexandria	0.28	1.07	1.12	3.86	3.47	4.20	5.26	3.20	1.18	2.41	0.40	0.82	30.54	March, 1882, to Feb., 1884. Record of voluntary observer.
Fort Bennett	0.73	0.64	1.01	2.20	2.58	3.97	2.17	2.21	1.24	0.69	0.29	0.45	17.85	Oct., 1880, to Nov., 1885. Record of Signal Service.
Bismarck	0.54	0.64	1.05	2.78	2.91	3.40	2.28	2.60	1.24	1.19	0.75	0.77	20.10	Oct., 1874, to date. Record of Signal Service.
Fort Buford	0.55	0.45	0.50	1.28	2.32	2.79	1.75	1.62	0.72	0.96	0.49	0.65	13.91	July, 1874, to date. Record of post surgeon prior to Jan., 1879; Signal Service since.
Deadwood	1.04	1.26	1.99	5.02	4.70	3.69	2.33	2.12	1.38	1.84	1.35	1.50	28.23	Jan., 1878, to date. Record of Signal Service.*
Firesteel	0.55	0.28	5.18	2.12	3.87	2.92	4.38	2.92	3.10	1.00	0.78	0.32	27.60	Feb., 1875, to June, 1877. Record of voluntary observer.
Fort Hale	0.39	1.09	0.96	1.43	3.00	3.71	2.39	2.52	0.70	2.32	0.25	0.49	19.62	Jan., 1879, to May, 1884. Record of post surgeon.
Huron	0.21	0.34	0.70	2.72	3.73	4.14	4.32	3.37	1.85	1.86	0.66	0.39	23.65	July, 1881, to date. Record of Signal Service.
Lower Brule Agency	0.20	0.18	0.82	1.86	1.81	1.80	3.27	2.91	2.01	0.44	0.34	0.79	15.13	Sept., 1875, to Dec., 1878. Record of post surgeon.
Fort Meade	0.71	0.56	1.18	2.80	4.43	2.73	1.98	1.82	0.49	0.73	0.51	0.49	19.22	July, 1879, to date. Record of post surgeon.
Morriston	0.58	1.28	1.86	2.77	4.26	4.69	4.51	3.44	2.17	1.97	0.52	1.04	31.03	July, 1877, to July, 1884. Record of voluntary observer.
Olivet	0.84	1.14	0.94	2.51	4.86	4.57	2.93	3.02	2.14	2.30	0.34	1.26	26.56	June, 1877, to Nov., 1882. Record of voluntary observer.
Pembina	0.46	0.76	1.00	1.59	2.91	3.78	2.53	2.34	1.52	1.67	1.42	0.99	21.91	July, 1874, to date. Record of post surgeon and Signal Service.
Fort Randall	0.44	0.87	1.58	2.74	4.36	5.18	3.67	3.02	2.39	1.83	0.55	1.35	28.99	July, 1874, to date. Record of post surgeon.
Fort Rice	0.24	1.23	1.04	3.60	4.15	2.64	1.51	1.10	1.39	1.24	0.90	0.73	15.01	July, 1874, to Oct., 1878. Record of post surgeon (incomplete).
Richardton	1.50	0.87	1.00	3.41	2.65	4.20	6.98	3.53	1.30	0.83	0.93	0.97	28.17	Feb., 1884, to date. Record of voluntary observer.
Fort Seward	0.05	0.11	0.89	1.15	3.23	3.37	1.87	1.78	1.57	0.65	0.08	0.10	15.08	July, 1874, to Aug., 1877. Record of post surgeon.
Fort Sisseton	0.37	0.40	1.05	2.14	2.63	3.58	3.46	2.37	1.37	1.99	0.61	0.62	17.23	Sept., 1876, to date. Record of post surgeon.
Fort Stevenson	0.37	0.44	1.09	1.34	2.33	4.13	1.70	2.91	1.40	0.96	0.49	0.43	19.11	July, 1874, to May, 1883. Record of post surgeon to Feb., 1879; Signal Service to 1883.
Fort Sully	0.42	0.38	0.72	1.95	2.77	3.42	3.06	2.13	0.94	0.63	0.48	0.59	17.39	July, 1874, to date. Record of Signal Service and post surgeon.
Vermillion	0.96	0.40	1.30	2.97	1.69	2.88	2.35	3.87	2.18	1.58	1.35	0.52	19.19	Jan., 1884, to date. Record of voluntary observer (incomplete).
Fort Wadsworth	1.86	0.58	2.65	2.35	2.26	1.87	1.95	4.12	1.33	1.63	1.45	2.19	25.73	July, 1874, to Aug., 1876. Record of post surgeon.
Webster	1.58	2.89	2.46	4.87	6.18	7.24	6.30	2.53	3.18	4.34	1.86	2.11	44.61	June, 1882, to date. Record of voluntary observer.
Yankton	0.56	0.82	1.29	3.39	4.45	4.81	3.74	3.05	2.93	1.66	0.67	0.72	28.43	April, 1873, to date. Record of Signal Service.
Fort Yates	0.34	0.23	0.46	1.84	1.51	3.34	2.57	1.87	0.75	0.50	0.32	0.57	14.27	Jan., 1882, to date. Record of Signal Service and post surgeon.
Fargo (Moorhead)	0.73	0.92	0.80	2.39	2.97	4.37	4.85	3.42	1.95	2.77	1.22	0.78	27.17	Jan., 1881, to date. Record of Signal Service.
Fort Totten	0.36	0.57	0.90	1.59	2.70	3.40	2.40	2.87	1.03	1.39	0.68	0.62	18.34	July, 1874, to date. Record of post surgeon to Jan, 1884; Signal Service since.
Mean monthly annual precipitation for Territory	0.70	0.72	1.26	2.50	3.20	3.64	3.10	2.65	1.59	1.47	0.71	0.81	22.35	

* Observations taken at Lead City from June to October, inclusive, 1878.

NOTE.—The latest observations included in above calculation are those of December, 1887. The winter of 1888–'89 not being normal, the figures are omitted. The precipitation of 1889 was the smallest ever known.

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These observations and others made show that the Dakotas have sufficient rain-fall to mature all crops, if it comes at the right time. This does not always occur, and crops suffer. The table shows 22.35 inches of rain-fall and melted snow for the year. Beginning with January, the month of the year when the least moisture is precipitated, there is a slight increase of snow-fall in February, which is nearly doubled in quantity by the rain and snow-fall in March. In April the average rain-fall is 2.5 inches, or twice the depth of moisture falling in the preceding month. This is increased thirty per cent. in May, the average precipitation of the month being 3.2 inches, while in June, at just the time the rain-fall is most needed to benefit the growing crops in this region of late harvests, the maximum precipitation during any single month of the year is reached, averaging 3.64 inches. During the last half of the year the amount of moisture precipitated each month lessens in about the same ratio as it increases during the first half. By seasons we have the following result: In the winter months the total precipitation averages 2.26 inches; in the spring, 9.96 inches; in the summer, 9.39 inches, and in the fall, 3.77 inches.

There is a difference between the eastern and western sections of the two States. The line of the Missouri River will divide them enough. On the west, irrigation will be needed on a large scale. Storage in reservoirs, distribution by high line canals, is a necessity there. East of the river, small storage, local impound, and wells will be of the greatest value.

The altitude of Dakota above sea-level ranges from 800 feet in the Red River Valley to 2,000 on the high prairies between the large rivers, the average of the Territory being about 1,500 feet. The most elevated section is the Black Hills, where the prairies and table-lands gradually increase in height from 2,000 feet to the culminating points, 7,000 to 8,000 feet above the level of tide-water.

North Dakota has 74,312 square miles and South Dakota 76,620, each one still larger than any one of sixteen of the States. The great size of the Territory can be understood by comparing it with foreign countries, it being larger than England, Scotland, Ireland, and Wales combined, larger than Norway or Italy, twice the size of Turkey, four times as large as Portugal, and ten times the size of Denmark.

The two new States are distinctly a prairie country, yet there are two mountainous regions. The larger of these is known as the Black Hills, and while it laps over into Wyoming, it covers an area in South Dakota of about 4,000 square miles. The highest point of the Black Hills, Harney Peak, reaches an altitude of 8,200 feet above the sea, while other peaks vary from 6,000 to 7,500 feet, the average elevation of the entire region being about 5,000 feet, or from 2,500 to 4,500 feet above the surrounding plains.

The Turtle Mountain region lies in Northern Dakota, and includes an area of 800 square miles along the international boundary line. It consists of ranges of hills hardly high enough to be dignified by the name of mountains, rising, as they do, but a few hundred feet above the surrounding prairies. There are only two prominent peaks, Butte St. Paul and Bear Butte, each about 3,200 feet above the sea, and only 700 feet higher than the rolling plains below. This region, as well as the Black Hills, is well timbered.

The two States have a water surface estimated at about 1,500 square miles. Their principal rivers are the Missouri, James or Dakota, Big Sioux, Vermillion, Red, White, Green, Bad, Cheyenne, Moreau, Grand, Cannon Ball, Heart, Sheyenne, Little Missouri, Mouse, and Maple.

The Missouri, varying in width from one-half of a mile to two miles,

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is the most important. It flows in a general southeastern direction, through a course, counting its windings, of fully 1,300 miles, dividing the Dakotas into two nearly equal divisions. Analysis has proven the water to be the purest river water in the world. Dakota, with the Red River of the North, the Missouri, makes the navigable waters of the Dakotas.

The area of the two Dakotas is computed at 96,596,480 acres. Indian reservations take up 26,847,105 acres of this great area, soon to be reduced, however, 11,000,000 acres by the opening of the Sioux Reservation. Out of the total there is also to be deducted 7,000,000 acres granted to the Northern Pacific Railroad, and 3,000,000 set apart for a school fund. Up to September 30, 1889, according to report of the various land offices, there has been disposed of 40,184,895 acres, under the various land laws. The unoccupied lands are distributed between the various land districts, four in North Dakota and five in South Dakota, as follows:

North Dakota.

	Acres.
Bismarck land district	11,622,500
Grand Forks land district	560,200
Devils Lake land district	4,182,930
Fargo land district	263,833
Total number of acres	16,629,463

South Dakota.

Huron land district	189,100
Yankton land district	14,097
Rapid City land district	986,189
Mitchell land district	5,000
Aberdeen land district	747,940
Watertown land district	44,960
Total number of acres	1,987,286

There are 3,431,000 acres of unsurveyed land in the Rapid City district to be added to the total of South Dakota, an acreage, too, soon to be increased by the opening of 11,000,000 acres of the Sioux Reservation. From the Aberdeen district, however, a deduction of 113,860 acres located in North Dakota must be made.

Prior to 1862 any land taken up in Dakota was by purchase or pre-emption, the homestead law not becoming a law until May 20, 1862. From that date to June 30, 1863, there were 75 entries under this act, involving 11,829 acres; in 1864 there were 111 entries; in 1865, 64; in 1866, 154; in 1867, 187; in 1868, 614; in 1869, 523; in 1870, 576; in 1871, 861; in 1872, 1,009; in 1873, 1,297, and in 1874 1,778 entries, involving 288,162 acres. From 1875 to 1889 the entries under the homestead, pre-emption, and timber culture acts have absorbed land as follows:

	Acres.		Acres.		Acres.
1875	205,918	1880	2,268,808	1885	4,547,749
1876	391,645	1881	2,673,213	1886	3,075,085
1877	212,555	1882	4,360,131	1887	2,069,668
1878	1,377,948	1883	7,317,236	1888	1,838,142
1879	1,656,851	1884	11,082,818	1889	2,382,948

AGRICULTURE AND IRRIGATION IN WESTERN KANSAS AND NEBRASKA.

The Great Plains, estimating as such the semi-arid and arid territory between 97° 30′ and 103° 30′ and from British America to the Red River south, that is over 6 degrees, or 400 miles east and west, and north and south about 700 miles, will contain at least 180,000,000 acres.

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Profs. Samuel Anghey and C. D. Wilbur, of the University of Nebraska, are scientists of repute, authors and teachers of recognized capacity. Their opportunities of direct observation so well supplement these qualifications that the testimony and views presented by them must be esteemed of a weighty character. The conclusion they arrived at as against the continued aridity of the Great Plains can be stated as follows:

(1) The soil embraced within the area west of the one hundredth meridian "is chemically equal to any similar area of soil taken in any part of the American continent." The professors do not include either Arizona or New Mexico, yet both are equal to the other portions of the area indicated.

(2) Water is the only element lacking to insure complete productiveness.

(3) The homogeneous character of the soil is insured by the fact that it is the result of "the decomposition of primary rocks, old sea deposits, and glacial agencies, acting through long ages over great areas of both mountains and plains."

(4) The practical question to be settled, then, is the supply of moisture.

Messrs. Anghey and Wilbur hold it to be proved beyond reasonable question that "the present rate of increase in rain-fall will in a comparatively short time fit this region for agriculture without the aid of irrigation." They argued at length in the paper mentioned, as also in other publications:

(*a*) "That the actual rain-fall from the ninety-eighth meridian westward, over a considerable area, is sufficient to produce successfully root crops, fruits, and the cereals." Nearly up to the North Platte the rain-fall averages 26 inches per annum, and beyond that for a long distance west it amounts to nearly 16 or 17 inches. It falls, too, in the early summer, when most needed.

(*b*) That the presence of nutritious grasses proves the richness of the soil. The buffalo grass as it disappears is everywhere followed by other species, far more useful, belonging to the same family of plants as the edible grains. The spontaneity and variety of the native flora on the Great Plains are also indicative of the richness and adaptability of the soil.

(*c*) Holding that the moisture and rain-fall are gradually increasing from east to west, Messrs. Anghey and Wilbur declare—

(1) That actual tests, taken in large number, show the practicability of "grass and grain growth in the major part of the lands of the United States domain excepting actual rocky areas.

(2) It is also shown by "the western march of grass and grain growth" in Nebraska almost to the western limits of the State, 350 miles from the Missouri River; in Kansas clear up to the one hundredth meridian and (except as to grain on the uplands, or water-shed regions, and in some parts along the valleys of the Arkansas and Smoky Hill) a long distance beyond that line, and in Dakota up to the foot-hill ranges of the dorsal mountains.

(3) That the actual increase of the rain-fall is clearly demonstrated by observations taken over a period long enough to give consecutiveness to the deductions made.

After citing various authorities, Messrs. Anghey and Wilbur sum up their conclusions in the following manner:

Observation, experiment, and the highest scientific authority demonstrate that climates in the West are becoming moister and that rain-fall is increasing steadily.

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This increase must extend steadily until the plains east of Denver and Laramie receive sufficient rain-fall to produce farm products.

For these reasons we are compelled to say that any evidence of present dryness, where dryness exists, is evidence only for the present and should not be used to cover these areas with the undeserved reproach or curse of desert lands.

By the term "these regions" Messrs. Anghey and Wilbur refer to the area usually designated as the "Great Plains," lying between the ninety-eighth west meridian and the higher foot-hills of the frontal range of the Rocky Mountains, though they appear to have more especially in their minds the more limited but still great basin of the Republican River, embracing a large portion of central and northwestern Kansas and the area contiguous thereto in Nebraska.

IN SOUTHWEST KANSAS.

Within the last ten years over 500 miles of irrigating ditches have been constructed in the Arkansas Valley west of the one hundredth meredian, in Kansas. These ditches are capable of supplying water for the irrigation of more than 100,000 acres of land in Ford, Gray, Finney, Kearney, and Hamilton Counties; but, owing to the failure of the water supply in the Arkansas River for the last two or three years, the ditches have not been used to their full capacity. This failure of water was caused mainly by the paucity of snow-fall in the Rocky Mountains in the winters of 1887 and 1888, and the severe droughts which have prevailed between the one hundredth meridian and mountains for the last three seasons. We think the current opinion that the numerous irrigating ditches which have been recently constructed along the Arkansas Valley in Colorado exhaust the water in the river before it reaches the Kansas line is largely erroneous. During the summer of 1889 there was more water in the Arkansas River at Dodge City than at Coolidge, near the State line. There was more at Wichita than at Dodge City, and more flowing water in the channel in the 200 miles in Kansas than in the 200 miles west of the Colorado line. That the supply of water is inexhaustible has been frequently demonstrated by pumping water from wells located in the valley. The two most noted experiments were made last year at the wells which supply the water-works at Dodge City and at Garden City. These wells are 22 feet and 19 feet in diameter; respectively, and about 20 feet deep; the water rises to within 4 feet of the surface of the ground. Over 1,000,000 gallons have been pumped out of the Dodge City well in a single day without lowering the water to any appreciable extent. At the Garden City well the water-works pump, with a capacity of 600 gallons per minute, and a Huffer irrigation pump, with a capacity of 500 gallons per minute, were both worked to their utmost limit for a period of four hours without lowering the water in the well. Numerous other experiments of a similar nature have been made.

IRRIGATION VALUES AND CONDITIONS.

Civil Engineer Tweeddale, of Kansas, writes as follows:

The question of the supply of any desired quantity of water for irrigation from the underflow being assured, we will consider the subject of its procurement, etc., in the following order: First, the quantity of water required for irrigation, generally and specifically; second, the manner of its procurement from the under-ground current; third, the cost of plant for procurement and distribution; fourth, the results of irrigation and a comparison of it with "dry farming" when the rain-fall is deficient, and also when it is ordinarily considered ample for "dry farming," together with a comparison of the methods in general use of distributing the water from open ditches by means of rills opened and closed with shovels or hoes; and of distributing pumped water from pipes by means of hose and hydraulic monitors attached to plugs or hydrants.

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First. The quantity of water required for profitable agriculture depends upon the nature of the soil, character of the crops, and the position of the district in relation to the surrounding country. Thus in the case of a permeable soil with considerable declivity the water deposited upon it will pass off rapidly, perhaps even before serving for the germination of the seed or the nutriment of the plant. If, however, the soil be retentive and the site low as compared with its surroundings, the soil may become so saturated with water that germination and growth may be greatly impeded. The conditions necessary for the germination of seed and the growth of plants are moisture, air, and a certain degree of heat. In a clayey, impervious soil an excess of water will act injuriously by reason of the absence of air and heat. In the case under consideration, the soil being impervious and the ground having sufficient declivity to give surface drainage, the discharge will be large. Add to this an elevated temperature, a clear sky, and dry air—in brief, a normal drought—and we have all the conditions which require frequent and plentiful waterings. In the process of vegetation water is the medium through which plants obtain nourishment. The water, charged with the organic and mineral substances in a state of solution which constitute the food for plants, is drawn up through the roots; these substances are assimilated and the water thrown off through the leaves. Many experiments have been made to determine the amount of water transpired by plants. M. E. Risler, a Swiss philosopher, has recently given a good deal of attention to this subject. He operated both in the laboratory and by observing the flow from the drains of a field especially arranged for such observation. He gives the daily consumption of water for different kinds of crops as follows:

	Inch.	
Lucern grass	0.134 to	0.267
Meadow grass	0.122	0.287
Oats	0.140	0.193
Indian corn	0.110	1.570
Clover	1.140	
Vineyard	0.035	0.031
Wheat	0.106	0.110
Rye	0.091	
Potatoes	0.028	0.055
Oak trees	0.038	0.030
Fir trees	0.020	0.043

Schlieden, at Jena, found for a mixture of clover and oats grown in earth contained in an iron box, which was weighed at intervals to determine the evaporation, a consumption of about 0.0984 inch per day from the time of sowing until the time of harvesting, a period of one hundred and twenty-nine days—13 inches nearly. Very careful experiments on this subject have been in progress for several years at the observatory of Mountsouris, in France. The grain is grown in earth contained in metallic boxes, and similar boxes without grain are used to determine the evaporation. In some cases the earth was dried and weighed both before sowing and after harvesting. The results obtained were essentially as above given. It was found that to produce one pound of wheat required the expenditure of from 800 pounds to 2,400 pounds of water, the lesser quantity being when the soil was fertile. In the case of wheat the maximum consumption of water occurred at the period of flowering, after which it diminished to the ripening, and then ceased.

From the above table it appears that a field of grain (as wheat, oats, or rye) may absorb, between seeding and harvesting, 15 inches of water, while grass may absorb 37 inches during a period of growth of one hundred and thirty days. This question of the effect of water on fertility explains the difference observed in the yield of different fields of grain at the same time, and of different yields of the same field in different years. It also serves to explain some points in hydrology, as to the effect of the destruction of forests on the flow of streams. The table shows that the quantity of water transpired by the leaves of cereals is greatly in excess of that by the leaves of forest trees, which proves that the clearing and cultivating of forests do actually diminish the quantity of water in the streams. It also explains how lands rich in the chemical constituents of certain grains produce large crops with a small rain-fall, as in the case of northern Dakota and Minnesota, where, with a rain-fall of but 17 inches, 30 and 35 bushels of wheat to the acre is not an uncommon yield.

* * * * * * *

The advantages in favor of irrigation are: not only are the crops much larger, but they are entirely unaffected by drought or wet; and being harvested under a clear sky are in good condition, and therefore, being of superior quality, command higher prices. As a rule, persons living on irrigated lands, having regular occupation, are more thrifty; their crops are certain, regardless of seasons; having larger and more certain incomes, their earnings are expended in increased comforts—all of which increases the business of railroads. And now that the competition between rival lines has destroyed the profits of through traffic, dependence must be placed on local busi-

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ness, which for that reason must be developed, resulting in the charges for the hauling of coal used for pumping being the least possible. As the effect of an extensive system of irrigation is toward small holdings and a dense population, the result will be increased business. It is estimated that 1 acre of irrigated land produces, directly and indirectly, more than 1 ton of railroad freight annually, or more than two hundred times as much as the same land used for grazing cattle, as the effect of any considerable amount of irrigation would, by increasing the humidity, tend to a reclamation of the unirrigated desert, and in a measure affect the humidity of the whole area.

Perhaps the clearest and most simply stated description of irrigation as at present practiced among us is the following, from the pen of Orange Judd, the veteran editor of the Prairie Farmer:

Irrigation in the present use of the term means the artificial application of water to the soil, by several methods. There is the "main canal" or ditch, which brings water taken from streams that may be a mile or two or scores of miles away. A "lateral" comes out of one side, and extends several rods, or even miles, to the upper side of a field, into a plow furrow nearly on a level, and the water in this case spreads out each way. From this head furrow very small ones are made with a hoe, or quicker with a small single-horse plow. They are run in such direction, required by the lay of the land, as will give them only a slight descent. A hoe or shovel full of earth into the plow furrow at each entrance of these little ditches keeps them closed. When the land needs water the little "gate," or sliding board at the canal, is raised as far as needed to let in the required amount of water. This is raised or lowered from time to time, as seen to be necessary. The large plow furrow being filled with water, the irrigator opens or closes the upper ends of the small furrows by taking out a shovel or hoeful of earth. The operator walks over the field, and where water enough is not flowing out in any place, he, with a shovel or hoe, clips off a bit of earth from the side of the small ditch or furrow, or stops the flow at any point by throwing in a trifle of soil. In this way he can, in an hour or two, give an entire field what would be equal to a heavy soaking rain. This may be done so deeply down, one or even two feet, that the growing crop may flourish through the hottest season or drought without another irrigation.

Where water goes deep down it is only very slowly evaporated from the surface, while the roots of the crop grow downward so far as to find a good deal of natural moisture in the soil. Usually only two, or at most three, such irrigations are needed on a wheat crop, grown on a soil which is literally a dry ash heap. The number of irrigations and the amount of water at each flowing depend a good deal upon the character of the subsoil. Some land requires only a single flowing, along in May or June. Sometimes a flooding about the heading-out time will produce very heavy grain kernels. Sometimes the ground is well flooded before the seed is sown, and once or twice afterward, unless there is an unusual fall of rain. Most farmers using irrigation rather prefer no rain. Having a supply of water in the canal to use whenever needed, they prefer continual hot sunshine, which pushes growth forward most rapidly.

In most of the irrigable, arid regions, these canals are taken out high up a river or stream which is fed by the melting of snows on the mountain tops in May, June, and July, just the time when plenty of water in the canal is most needed. The canals are carried along with a descent of 1½ to 2 feet per mile, winding around hills or uneven ground to maintain a uniform grade. If the ground and the stream descend rapidly the canal may thus be carried scores of miles, and at its end be 20, 50, 100, or more feet above the parent stream. The side canals are taken out at different places, and similarly carried over or around uneven land, so that a single main canal may irrigate tens or hundreds of thousands of acres, for example a canal from a stream in the Rocky Mountains, by following the sides of knolls, valleys, and hills, may take water hundreds of miles to supply the parched farms in Eastern Colorado.

It was asserted by the Public Land Commission in 1880 that the arable area of the United States would be all taken up by 1883. Francis A. Walker said the same thing; other writers and publicists also repeated it. Yet the Land Office reports show that since 1883, and up to June 30, 1889, 109,377,858.14 acres of public lands have been disposed, within the States of California, Colorado, Nevada, Oregon, Kansas, Nebraska, Washington, Montana, North and South Dakota, Idaho, and Wyoming, and the Territories of Arizona, New Mexico, and Utah, alone. Of this total certainly 60,000,000 acres are within the arid region proper, and the major portion of the balance was located and settled within the semi-arid sections, and all of this was classed as "agricultural."

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IRRIGATION ENGINEERING PROBLEMS.

STORAGE OF THE STORM AND MOUNTAIN WATERS.—RESTORATION OF DRAINAGE, UNDERFLOW, AND SEEPAGE SUPPLIES.—RESERVOIRS, CANALS, WELLS, SUB-DAMS, FARM STORAGE, ETC., ETC.

PART II.

In the work of irrigation survey, at present there seems to be two distinct points to be aimed at. In a great measure the running waters within the arid region are being rapidly consumed. The points are, first, the conservation of the storm or surplus waters, which must necessarily be stored in the high altitudes of that region, and, secondly, the restoration for use in agriculture of the waters under the earth.

These two divisions at the present moment seem to be the essential purposes for which engineering efforts should be made. It is suggested that the great area lying east of the Rocky Mountains—the plains and foot hills—from the 97th practically to the 104th degree of west longitude must come first, because of the great population that has gone in there, and of the large amount of struggle and of pecuniary effort that have been made by them, and owing to the condition in which they are being constantly placed by reason of the insecurity or uncertainty of the water supply. These conditions arise, not so much by the deficiency of the water supply, taking the years through, as by its unequal and unsuitable division. What is called the great plains region has, for the work of reclamation, at present, to be now considered, upon the ground that a large part of the population to be benefited by irrigation are to be found there.

The problems involved in that fact are, of course, two-fold, as in the whole field: These are the storage of the surplus waters in the Rocky Mountains proper and in the valleys of the streams flowing there, and the obtaining of an adequate knowledge of the waters within the earth, so as to make plans and lay out the best methods for their economic use in the near future.

The artesian water-belt, the most remarkable of which is found in the central valley of the Dakotas, is first to be considered. Second, comes the underflow or sheet water of the river valleys. Then one of the most important is the general seepage or drainage waters found to exist in the gravel and sandy strata just below the alluvium, all through the central portions of the plains, and which, it is believed, by shallow openings or wells can be collected so as to be restored to the surface and distributed by mechanical or pumping power. In this connection the testimony of Mr. George H. West, of Greeley, Colo., relating both to west Kansas and eastern Colorado is of great value in relation to this purely American application of mechanical power in the use and distribution of water for irrigation. Mr. West says:

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THE DRAINAGE SUPPLY.

In the southwest section of Kansas, south of the third standard parallel and west of the ninety-eighth meridian, embracing an area of 16,520,000 acres, it is claimed that there are fully 15,000,000 acres suitable for agricultural purposes, relying for its best results upon irrigation.

At least 90 per cent. of this land is underlaid by subterranean flows or reservoirs of water, available from wells by means of mechanical power. The application of an economical method of raising this water would produce more immediate and general benefits than any other system, making from 60 to 75 per cent. of the entire area at once reclaimable by private enterprise.

Along the Cimarron River and its tributaries are 350,000 acres of first bottom lands, with abundance of water within 20 feet of the surface; while at least 500,000 acres in the Arkansas Valley will afford an exhaustless supply of water for ordinary irrigating purposes at 10 feet. The valleys of the Beaver, White Woman, Pawnee, Walnut, and their tributaries will afford 1,000,000 more acres of land, with an ample water supply from 15 to 30 feet. Outside of the valleys sheet water is found, from 30 feet to 100 feet, with an average depth of about 60 feet; excepting limited areas, including portions of nearly every county west of the ninety-ninth meridian. Embracing nearly all of Haskell County and a narrow strip west through the counties of Grant and Stanton, and east through Gray, Ford, Kiowa, and Pratt, extends what is known as the deep-water belt, or high divide. Another such area extends west through the counties of Garfield, Finney, Kearney, and Hamilton, along the fourth standard parallel. In these belts water lies at depths generally exceeding 100 feet. Outside these narrow belts the larger portion of the entire area is underlaid by a water supply, available to a mechanical method of raising it. The water is almost universally found running through gravel beds with a uniform current towards the east. Neither coal or wood is found in this territory. Prices are governed by the length of haul and competition between lines of railroad. At Garden City the best Cañon City coal sells at the scales for $6.75 per ton, Trinidad coal $5.90, and Cañon City pea coal $4.65 per ton.

No pumping system or irrigation has been tried, and the surface streams are totally inadequate to furnish an extensive water supply for a system of canals. The Arkansas River is the only stream that can be utilized in that manner. The present demand upon it renders farming more hazardous than will justify further development in that direction without the application of a storager-eservoir system, or in tapping the water-bearing strata with underground canals—taking advantage of the universal trend eastward. Such a system will be necessary to reclaim the high divides mentioned in this report, and will call for reservoirs of enormous capacity, as those lands being uniformly unbroken, storage-basins must be made at great distances from the areas to be watered.

The underground water supply will rapidly increase instead of diminish, as the water used will largely be absorbed by the soil and percolation from above be added to the present sources. The water lost by evaporation will be replenished by the rain that will be enabled to soak into the soil, instead of wasting upon the impenetrable sod of our prairies. Kansas farming has demonstrated that breaking the sod and continued cultivation of the soil will eventually result in the complete saturation of that dry soil, which almost invariably exists from the sod to the sheet water. The almost entire absence of clay beds and other impenetrable substrata will permit of the complete saturation of the soil down to the present water-levels, making a storage-reservoir of incalculable magnitude, proportionately increased by each additional demand upon it, and capillary attraction, now almost entirely absent, will soon be established.

By determining at once the practicability of mechanical means of raising water from our wells these results can be acccomplished by private enterprise in time to benefit the classes who must need aid and encouragement, and who are utterly unable to wait upon the action of the Government in devising and executing a more elaborate system of storage and canals. A pumping system will permit of individual enterprise and general adoption at once. Any system dependent upon the construction of expensive canals, reservoirs, sub-drainage, or other methods involves unavoidable delay of governmental action, or in inducing capital to come to our relief. To demonstrate that a pumping system can be practically and economically applied will greatly reduce the area of arid lands to be reclaimed, and afford a proportionate increase of the available water for that purpose.

THE WATER-BEARING GRAVELS.

The valleys of Colorado on the eastern plateau have all been formed by denudation; the streams from the mountains have left on the bed rock deposits of sand and gravel filled with water, varying in thickness from a few inches to 64 feet at Eaton, Colo. This bed of water-

bearing sand and gravel in the Cache-la-Poudre Valley extends from Greeley to the foot of Chalk Bluffs, 39 miles north and 1,220 feet higher. This increase of altitude is of value. Near the foot-hills large bowlders lie next the bed-rock, and farther east on the plains their size decreases regularly to large stones, coarse gravel and sand, all filled with water. From the surface to bed-rock the conditions are reversed, and below the soil we reach quicksand or sand, then fine gravel, coarse gravel, large stones, etc. Water is usually found on the plateau east of the mountains as soon as the gravel is reached, and back from the rivers for miles in the valleys water is usually found beneath the surface at the same level as in the surface streams. The water-bearing strata near the surface is comparatively narrow at the foot-hills, but widens out many miles as we reach the valleys, where the surface streams have less fall to the mile. Since the construction and use of irrigation ditches the amount of water in the gravel strata has greatly increased, often standing much higher than the level of water in the natural streams, and coming to the surface as seepage in lakes and ponds.

The distance from the surface to the subterranean water varies from a few feet to more than 50 feet in the valleys of the Cache-la-Poudre, South Platte, and Big Thompson Rivers and their tributaries. At Greeley, in the river valley proper, water is found from 4 to 16 feet from the surface, and the water-bearing gravel is 44 feet thick; at Eaton, 8 miles north, this water strata is 20 to 25 feet from the surface and is 64 feet in depth; at Pierce, 10 miles still farther north, this water strata is 30 feet from the surface, and continuing 20 miles again north, to the Maynard Flats, near Carr Station, water is but 8 feet from the surface, in gravel. The depth of the water-bearing strata in the latter locations have not been determined. Water is found also in gravel on Crow Creek and Little Crow Flats, 40 to 50 miles northeast from Greeley, at varying depths from 4 to 20 feet, in large quantities. At Denver bed-rock comes to within a few feet of the surface, and good results have not been obtained; but large amounts of water are found in the sands of Cherry Creek and in the valleys adjacent thereto. North from Denver, along the South Platte Valley, water is found at varying depths from 8 to 30 feet, and the water-bearing gravel is 50 feet thick at Brighton, 55 feet at Fort Lupton, 60 feet at Platteville, and 86 feet at Evans; 100 miles still east, at Sterling, Colo., water is 4 to 20 feet from the surface, in sand and gravel. The gravel there is much smaller than at other localities named, and there is more quicksand above it.

The amount of water that may be stored in a cubic foot of sand or gravel, when fully saturated, has been ascertained by careful experiment to be as follows: Fine sand 2 gallons, coarse sand 2½ gallons, sand and fine gravel 3 gallons, coarse gravel and small stones the size of hen's eggs 3.6 gallons. As a cubic foot contains 7.5 American gallons, it will be seen that very large gravel beds contain fully one-half water. Water is found in all the dry creeks and the valleys adjacent thereto in northern Colorado, east of the mountains, at varying depths from 2 to 20 feet. Actual tests have been made verifying this matter on Lone Tree, Big Crow, Little Crow, Wild Cat, Pawnee, Lewis, and Cedar Creeks north of the South Platte River, and on Cherry Creek, Sand Creek, Lost Creek, Box Elder, Kiowa, Bijou, Big Beaver, and Little Beaver south of this river. As investigation goes on the area of land known to have underground reservoirs of water at a nominal depth from the surface is largely increased.

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This gravel is very coarse, in places as large as your fist. That lies together irregularly, and there are great spaces or cavities between the pieces. As we pump the tendency is to throw this stuff out and open up great channels, and then there is a rush in of water. On the Albert Howard well, which is 70 feet deep and gives 22 feet of water for irrigation, there are two pumps for the 200 acres, and the water is lowered about 11 feet in pumping twelve hours per day. That leaves 11 feet to draw on. The amount of water underneath in these gravel beds seems to be enormous. Where we have found 12 feet of water in that stratum we have not put in any pumps yet that have pumped it dry. At Platteville, about 20 miles south of here, they have 60 feet of that gravel stratum, and nearer to Denver they have 50 or 55 feet in different locations.

We have under Greeley 46 feet of gravel stratum filled with water. We have first four to six feet of surface drift or soil, and below that comes this gravel filled with water, which extends down 46 feet farther to bed-rock. On the Platte Piver, east of here, we have 84 feet of that gravel stratum filled with water. We find that in many of these dry creeks or arroyos there is water at a slight depth and also in the flats. At Crow Creek, 40 to 45 miles northeast of here, where there is only a little water in places coming to the surface, they find large quantities of water there at from 4 to 15 feet below the surface over a large area.

In twenty counties in Colorado, lying east of the base line, which runs through Pueblo, there are some 25,000,00 acres of land. Fully 20,000,000 acres of this is suitable for cultivation, and probably one-fourth of this, or 5,000,000 acres, are underlaid with an ample water supply near the surface, available for use for irrigation by mechanical power—that by lifting or pumping.

THE UNDERFLOW WATERS.

Mr. W. Tweeddale, civil engineer, of Topeka, in broaching a plan for distributing water for irrigation by means of electricity, has this to say about the rain-fall on the plains:

In Texas, with 20 inches of rain-fall, "dry farming" is not profitable; while in Dakota, Minnesota, and Nebraska 16 inches of rain-fall gives good results. The reason for this is that in Texas the temperature is high, and the rain-fall uniformly distributed throughout the year, while in the above-named States the temperature is much lower, and there is a well-defined rainy season giving 72 per cent. of the annual rain-fall during the spring and summer, while Texas has but 50 per cent. during the same time; for which reason 15 inches in the above States will be equivalent to 20 inches in Texas, with the further difference in their favor due to much lower temperature. The relative value of rain-fall for agriculture in the different localities will appear from a comparison of the tables of rain-fall at eight selected stations in Texas, three in western Kansas, and eight in Dakota, Minnesota, and Nebraska. Of the annual rain-fall of these several stations, the amount that falls during the spring and summer is as follows: In Texas, 55 per cent.; western Kansas, 65 per cent.; Dakota, Minnesota, and Nebraska, 72 per cent.; from which it will be seen that the proportional part of rain-fall in western Kansas during the growing season is intermediate between that of Texas and the above-mentioned three States; and while that in western Kansas is but 11 per cent. less than in the above three States, the difference in effectiveness is much greater by reason of difference in temperature.

In a consideration of the subject of rain-fall, it must be borne in mind that in the so-called "subarid" region there is a great liability for many seasons in a long series of years to be without sufficient rain-fall to make agriculture profitable, in which case the whole supply of water for irrigation must be procured artificially. And as it is the certainty of results alone that will justify the investment of capital in new enterprises, it follows that in any scheme for furnishing water for irrigation estimates of cost must be based on being able whenever required to furnish the whole amount of water necessary for the profitable raising of any particular crop.

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In designing storage reservoirs of limited extent, account must be taken of the minimum annual and minimum periodic rain-fall. It sometimes happens that the annual rain-fall continues to be less than the general mean through cycles of three or four years. Computations based on a number of selected stations of largest observation in the United States, extending throughout the whole country, give the average annual rain-fall of the least three-years cycle, at any one of these points, as 67 per cent. of the mean annual rain-fall at the same point, and the greatest three-years low cycle as 97 per cent. of the mean annual rain-fall at the same point. Taking 16 inches as the mean annual rain-fall at Fort Dodge, the mean annual rain-fall of the low cycle will be 67 per cent. of 16, equals 10 inches. Of this amount, favorably situated gathering-grounds of unbroken prairie will furnish at least 60 per cent. This will give a depth of 6 inches of water over the whole area drained for collection in a reservoir. Taking 16 inches depth of water over the area irrigated as the requirement in addition to the proportional part of 16 inches of rain-fall, and we have 16 divided by 6, equals 2⅔; *i. e.*, the water from 2⅔ acres of drainage area will furnish sufficient water to irrigate one acre of land. Doubling this amount for contingencies (as evaporation and seepage), and 5⅓ acres will suffice for one acre. On this basis the owner of a favorably-situated quarter-section of land can collect in a reservoir the required amount of water to irrigate 30 acres, which will allow 15 acres for agriculture, 15 for meadow, and 130 for grazing. The reservoir should be made deep, to prevent loss by evaporation. Should the gathering-ground be large, and owned by a number of persons, a reservoir of greater capacity might be constructed, and by purchase or exchange with each other, a unit of forty acres of irrigable land might be secured to each, with diminished cost per acre.

When, however, there is no suitable site for a reservoir, the rain-fall from the gathering-ground will run onto and be absorbed by the porous soil of the bottom lands. Pure sand, when saturated with water, will contain from 30 to 40 per cent. of its bulk, while gravel contains 25 per cent. The eminent scientist, Sterry Hunt, estimates that one square mile of sandstone 100 feet thick will contain, when saturated, water sufficient to sustain a flow of one cubic foot per minute for a period of thirteen years. Sandy soil at a certain depth is always saturated with water, which rises, after large accessions from rain, nearly to the surface of the ground, and falls again during periods of drought. In a region of sand and gravel a fall of 6 feet in the ground-water will give a discharge into the streams of from 40,000,000 to 50,000,000 cubic feet per square mile of ground. The water so held constitutes the reserve which goes to maintain the dry-weather flow of streams.

The water in the ground, like that in the streams, is in constant motion, although its rate is by comparison with that of streams very slow. The quantity of water flowing in an open channel 100 feet wide and 6 feet deep, with a fall of 1 foot per mile, is about 1,000,000,000 of gallons per day. The quantity flowing through a channel of the same dimensions and fall, filled with gravel, will not exceed 600 gallons at the same time. This extreme slowness with which the ground-water moves serves as a regulating sluice to the ground reservoir, securing it against rapid exhaustion.

From the above it is evident that the water stored in the porous soil of the bottom lands is the source of the water supply of the Arkansas River valley, rather than the flowage of the river, which in fact for a portion of the year acts as a drain to the valley rather than as a supply to the under-current. The longitudinal fall of the ground-water in the valley in western Kansas is about 7 feet per mile. The writer found by measurement that the fall of the ground-water from the Arkansas River to Cow Creek, a distance of 2 miles, near Hutchinson, was 8¼ feet per mile. Observations made during the construction of water-works for cities show that in ordinary sand and gravelly soil a fall of 7 feet per mile will give a rate of motion of the ground-water of about 1 foot per hour.

ARTESIAN WELLS AND THEIR ECONOMIC VALUE.

An artesian well is one in which an artificial vertical shaft is filled to overflowing by water, which enters it at some distance below the surface of the ground. The water may spout up with force and rise higher than the surface or it may barely reach the point at which it flows over. The conditions under which this can occur are the same as those which govern the supply of water to the upper rooms of buildings in cities. The reservoir with which the water-mains are connected must be higher than the place supplied; for the same reason the stand-pipe which takes the place of a reservoir in towns located in a level country must be

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higher than the tops of the highest buildings. This is made necessary by a well-known principle in hydrostatics, that a fluid will not rise in an iron tube higher than its source. There are some artesian wells whose flow is due to other than hydrostatic pressure here described, viz, to gas pressure and rock pressure, but these forces need no illustration. In nature the channel through which the water flows is more like a sponge than the orifice of a pipe. It is porous rock, sandstone, conglomerate, gravel, sand, or limestone more or less cracked or broken. The walls of a natural pipe must be impermeable and usually beds of clay or clay-shale serve this purpose. To get the head of water the beds of sandstone, shale, etc., must have a dip, *i. e.*, they must be higher at one part than another. The best conditions are when the rock strata take a basin formation, highest on the edge of a circular area, and a well sunk in the middle of the basin. It is to be understood that all the waters of the land are meteoric waters, having their origin in the rains and snows. If then the rain falls on porous rock on the upturned edge of a basin, which within the basin is overlaid and underlaid with impervious clays, a well sunk at or near the middle would be artesian.

The basin form is, however, comparatively rare in nature, but continuous dip of rocks in one direction is by no means uncommon, so that the form of a trough is more often found. If the relative position of porous and impervious rocks is the same, artesian wells may be found on the slope or at the lowest point. The general dip of the geological strata on the plains is from west to east, by south, as is also the slope of the surface of the country. The conditions for finding artesian wells are thus widely distributed.

Prof. P. H. Van Diest, of Denver, Colo., who has had an almost world-wide experience as an engineer in connection with artesian waters and wells, gives some interesting data, as a basis for the consideration of the economic uses of such supplies. He says:

I have had something to do in India with artesian borings and gathered some statistics about the amount of water which percolates the lower strata. In the Paris and London basins, by careful observation it was ascertained that a third of the water-fall on a certain extent of land gives a certain flow; that another one-third evaporates and is taken off by the plants, and that the last third percolates to the lower strata. How far that is the case here is difficult to know because there are no observations taken. That is the experience, however, in London, England, and Paris, France, where considerable artesian water has been got. Similar observations have been made in India. Batavia is now supplied with artesian waters after surveys made by me. No observations are made here, and it is difficult to say what the case is. From the very sandy condition of a great deal of the outcropping rocks in the arable regions of Colorado, a good deal must percolate to great depths. That is proven to be the case in Denver, the Denver basin having observations made in it to some extent.

The conclusion is that there must be considerable water running down to the lower strata. By borings that have been made (about two hundred flowing wells having been bored) we have observed that there are three different flows. Speaking of those flows, I would say that the upper flows, to which many wells have been bored, are very limited. The lower flows take water from a greater extent of country. Much trouble has occurred in the artesian diggings by the bad construction of the tubing. There are a great many of such basins here all along the foot-hills, and it has been proven that there is much loss, as, for instance, in the San Luis Valley, where they have had flows of water to a great amount. There would be a chance to apply water for irrigation. The same is the case in the San Bernardino Valley, in California, where over two thousand artesian wells are aiding in irrigation. They are under regulations, so that during the night they must be closed off with stop-cocks. Thus there is no *unnecessary* water flowing off. There are many streams that run east from here, such as the Bijo, the Badger, and other creeks, which at their best are all running streams and have considerable water. Over distances of 20 to 30 miles they are entirely sunk and lost. The Platte Valley is increased farther down in its flow. Without seeing it directly here, the volume of water in the Platte is increasing. It

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must be that the water from some of the mountains flows invisibly away, probably not at a very great depth. Perhaps at 15 or 20 feet deep there may be an impermeable layer and that it flows under the surface away. I think that that water could be made useful by pipes from a distance out, carrying the pipes to a place where the water is needed. Certainly a great deal of land could be redeemed by the percolation of water which is now lost.

SPRINGS, UNDERFLOW, AND LOST STREAMS.

In eastern New Mexico there is an extensive region of large springs, showing the existence of water under ground that comes by artesian force or otherwise to the surface. When we come to northern Texas, and to what are known as the Staked Plains and the Panhandle region of that State, there are in existence to-day a great body of wells some of which are artesian in character, but there are many that flow so near to the surface and with such force that it is evident that if these wells were sunk deeper they would have the artesian quality; they would strike that stream. It is a general belief that the water under the Staked Plains, the water from which these wells are supplied, has the character of a flowing stream. Some experiments have been made in the neighborhood of Marienfelt, Odessa, and Midland, on the Texas Pacific Railroad, which seem to indicate the correctness of that theory. The altitude lowers abruptly, and the land is of a totally different character. Beyond the westerly limit of the Staked Plains the land is all of a distinctively arid character, as arid as Nevada or Arizona. It has no precipitation exceeding 8 to 11 inches of fall per annum. But throughout northwestern Texas there is unquestionably a large underground water supply. The springs which come to the surface, the evidence of the wells upon Staked Plains and in the Panhandle region, indicate this. Indeed, the testimony all goes to show that there is supply sufficient if it could be brought to the surface to answer the purposes, by small storage, of almost that entire region.

In southern Arizona there are areas of underground supply that can be developed. The Santa Cruz River, for example, flows under ground to Maricopa, in the Gila Valley. It runs into the Gila River near that point. The Santa Cruz River rises a few miles below the southern line of the United States, in Mexico. It runs almost directly north to Tucson. Nine miles beyond Tucson it is lost under ground, and then for some 87 miles it flows under ground, until it enters the Gila and helps to swell that river. The valley of the Santa Cruz contains about 1,140,000 acres, a very large proportion of which, if there were water for it, could actually be brought under the most efficient horticultural use. It is a region admirably adapted for fruit. At the Mission of Tumacacori, and at Tubac, Calabasas, and other places, there are the remains of fruit gardens that the missionaries planted and used. In years past all the semi-tropical fruits have been growing on some farms that were maintained there against the Apaches The Santa Cruz River should be taken out, as near its source as possible, and distributed by means of high-line canals.

The land is very fertile. The river has a great drainage area at its head. It is fed by several very important small streams on both sides, and if it were taken out and placed in a new channel, and distributed over the valley, the entire region at and below Calabasas, for some 10 or 12 miles wide and 150 miles long, could be made a perfect garden. We used to fancy in years gone by, in traveling over the Cienega, north of Tucson, that we could hear the waters running under ground.

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We do not know whether that was a correct inference or not. Eastward, and lying beyond the Dragoon Mountains, will be found the San Simon Valley, or plain, known in the olden days as the principal route southward of the Apaches. Water can be got in the San Simon and Sulphur Valleys anywhere at from 8 to 40 feet below the surface. All through, in this low table-land, will be found wet places—the Mexicans call them cienagas. There are a number of ranches in that valley now supplied by such waters, either from wells or tanks and ponds. The San Pedro River also, between the San Simon and the Santa Cruz, rises in Mexico, as the Santa Cruz does, and can be, by storage near its head, made of much greater service than is now the case. Upon the plateau on which Tombstone is situated they have some artesian water. There are two flowing wells at that place.

Crossing into New Mexico, over the Chiracahua Mountains and beyond the eastern foot-hills of that range, Deming is reached and the table-land around it. Water has been found there within 25 or 30 or 40 feet of the surface. It is an important railroad junction. It is so near that slight pumping brings it to the surface, and makes it valuable for the small irrigation, for fruit and gardens, that is going on in that region. From what can be learned in relation to it it would be possible to develop the whole well and under-flow water there, and create a storage system which would bring a large proportion of that mesa or bench-land under cultivation for grass and root crops as well as for fruit. Through this region and up to the lower foot-hills water can almost always be found a short distance from the surface. Most of these little valleys of that region could be reclaimed by the use of small storage.

THE DAKOTA WELLS.

In no section of the United States can there be found so many artesian wells, of as great pressure and supplying as immense a volume of water, as those flowing in North and South Dakota. They are chiefly in the valley of the James River, and are in successful operation from Yankton on the extreme southern boundary of the territory to Grafton on the north, covering a distance of nearly 500 miles. In Yankton over a dozen wells, from a depth of 550 to 600 feet, pour forth a bountiful supply of water, the increase in the number of wells not having the least effect on the flow or pressure from the underground source.

There is nothing strange in the flow of artesian wells. The principle is precisely that of a reservoir system of water works, or of the artificial fountain. By storing a supply of water in a basin at some high point and carrying it in pipes to a lower level convenient water power is obtained. Nature has constructed a vast system of underground waterworks on the same plan, the pervious strata of sand rock underlying the earth's surface at various depths serving as pipes to convey the water from a distant reservoir or source of supply.

There are now more than one hundred wells in the two Dakota States, of remarkable pressure and supply. This does not include numerous flowing wells. At Yankton various factories now utilize the force furnished by the pressure of the underground current. Wells cost from $4,000 to $6,000. The pressure varies in different localities from 30 to 180 pounds to the square inch, and the flow from 50 gallons to 4,000 gallons a minute. The Woonsocket well (South Dakota) is much larger. The water is more or less mineralized, but the constituents are such as

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have imparted to the water undoubted hygienic and remedial properties, analyses showing the presence of carbonates and sulphates of iron, lime, magnesia, soda, sodium, potash, etc. Artesian water is almost invariably soft, and of excellent quality for general household purposes. The temperature of the water partakes of the internal heat of the earth.

The records kept by well-borers, showing the penetration of various strata, establish the fact that the Dakota geological formation contains all the essential features which scientists state are pre-requisites to flowing wells. The water is found in coarse-grained sand rock, which has above it a confining stratum of shale, clay, or lime rock.

WHAT THE BORINGS SHOW.

Yankton.	Feet.	Grafton.	Feet.
Yellow clay	45	Black loam	3
Chalk rock	40	White clay	25
Shale	160	Blue clay	250
Hard rock	3	Hardpan	20
Shale	105	Limestone	137
Sand rock	20	Quicksand	20
Shale	37	White sand	45
Hard rock	3	Slate	3
Sand rock	15	Water-bearing rock	25
Shale	17	Red rock or shale	60
Quicksand	30	Blue shale	16
Hard sand rock	4	Pink shale	11
Shale	27	Gravel	49
Hard rock	2	Red shale	46
Coal	1	Soapstone	188
Shale	26	Sandstone	5
Sand rock	10	Granite	12
Quicksand	15	Total	915
Shale	20		
Soft sand rock	30		
Total	610		

According to Professor Chamberlin, president of the Wisconsin (Madison) State University, and other geologists, the artesian wells in the Dakotas are situated east of the one hundred and first meridian, and, with the exception of the one at Pierre, they are east of the one hundredth meridian. They occur in great numbers in the Red River Valley, making a belt through the Dakotas, with adjacent portions of Minnesota and Manitoba, and making a second nearly parallel belt running from Yankton northward to Devil's Lake.

The successful wells of the Dakotas, thus far bored, can be arranged in four groups, with reference to the geological horizons from which they derive their water supply. These are, (1) wells of little depth which do not pass through the drift; numerous in the Red River Valley; (2) those which penetrate to the Cambrian rocks, as at Grafton, N. Dak.; (3) those deriving their water supply from the middle or upper portion of the Cretaceous, illustrated by a single well in the western part of Cass County, and by several wells in the Red River Valley which pass through the drift; (4) those penetrating to the Dakota sandstone, the basal member of the Cretaceous. This group is important, and is illustrated by numerous wells ranging from Vermillion and Yankton northward to Devil's Lake. The available data concerning these are given in the following

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Table of elevations, depth, pressure, etc.

Locality.	Depth.	No. of wells.	Diameter of bore.	Temperature.	Pressure (per square inch).	Elevation (surface above sea).	Surface of Dakota (above sea). °*Fah.*
	Feet.		*Inches.*	*Feet.*	*Pounds.*	*Feet.*	*Feet.*
Vermillion	350					1,150	
Yankton	610	15	6	62	32	1,196	616
Do	165				140	1,196	
Yankton vicinity		15				1,196	
Tyndall	600				122	1,418	
Mitchell	1,300					1,301	
Plankinton	1,500				140	1,528	
Kimball	1,100				95	1,788	
Chamberlain						1,363	
Letcher	600					1,300	
Woonsocket	1,300				250	1,308	
Artesian City						1,313	
Vilas						1,480	
Huron*	863		6	60	170	1,285	422
Brookings	900					1,636	
Miller	1,148		6	80	125	1,587	438
Highmore	1,552		5	68	25	1,890	338
Harold	1,300				80	1,801	
Hitchcock	965		3½—4½		186–218	1,139	
Redfield						1,300	
Frankfort						1,296	
Faulkton	1,300					1,595	
Gettysburgh	1,300					2,982	
Ashton	915		6	55	50	1,296	381
Andover	1,070		4½	64	90	1,476	406
Groton	960		5		187	1,301	341
Aberdeen	908	Many.	5⅝	60	140–160	1,300	396
Columbia	965		4½	60	176	1,304	329
Ipswich	1,270		6	65	70	1,530	260–300
Ellendale	1,087		4–5–6	65	125	1,453	366
Jamestown	1,476	2	6	70	95	1,400	50
Jamestown vicinity	1,321						
Devil's Lake	1,511		3½			1,470	39

Head, supply, and irrigation duty.

Locality.	Artesian head (above sea).	Water supply (per minute).	Areas irrigable by direct flow, allowing 4 inches for 3 miles.	Character of water.
	Feet.	*Galls.*	*Acres.*	
Vermillion		80	95	
Yankton	1,270	3,000	3,570	Slightly hard, drinkable, used in boilers.
Letcher		Large.		
Vilas				In process.
Huron	1,678	1,400	1,666	
Brookings		None.		Said to end in granite. Minnesota geological survey thinks this doubtful.
Miller	1,876	1,000	1,190	Excellent; good for all purposes.
Highmore	1,948	14	16.6	Soft and of good quality.
Pierre				In process.
Hitchcock				Used for irrigation.
Faulkton			71	Abandoned; drilling another.
Ashton	1,411	60		
Andover	1,684	300	357	
Groton	1,733			
Aberdeen	1,670	3,500	4,165	
Columbia	1,708	4,000	4,760	Soft.
Ipswich	1,692			Soft (slightly brackish).
Ellendale	1,742	600	714	Soft; not pleasant to the taste.
Jamestown	1,690	375	446	
Jamestown vicinity				Abandoned.
Devil's Lake	1,575	40	47	

One hundred gallons per minute will give 4 inches of water to 119.3 acres in three months.

* Two miles southwest is a large farm well, in depth, pressure, and volume, equal to the Huron town well, which is to be used for the irrigation of a large farm.

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The wells enumerated above derive their water from the Dakota sandstone. Those at Vermillion and Yankton were begun in the Fort Benton. The remainder were begun in the Fort Pierre and pass through the Fort Benton.

The North Dakota wells not included in the classes already noted are as follows:

Location.	Depth.	Strata penetrated.	Water supply.
	Feet.		
Grafton	915	Passed through stratified rocks to granite.	1,000 gallons per minute.
Tower City	670	Fort Pierre shales to Niobrara horizon.	9½ gallons per minute; rises 33 feet.
Casselton and vicinity	317-350	Passed through the drift into Cretaceous rocks.	Brackish alkaline, copious.
Amenia and vicinity	250-279	....do	Do.
Blanchard and vicinity (six wells)	300	....do	Do.
Mayville	395	....do	Do.

All of the wells enumerated in the last table, excepting the one at Tower City, are situated in the Red River Valley, and passing through the glacial drift enter older formations.

The one at Grafton passes through the Cambrain and into the granites beneath. Water was first reached at the depth of 503 feet; 400 feet deeper and resting on granite, a second sandstone stratum was reached which contained saline water. The well was continued 12 feet into the granite, but was subsequently filled so as to receive water only from the first water-bearing strata reached.

The remainder of the wells in the Red River Valley which pass through the drift are supposed to derive their supply from the middle portion of the Cretaceous.

The thickness of the Dakota sandstone as given by F. V. Hayden at its outcrop about the Black Hills is 400 feet. At Lincoln, Nebr., as stated by Professor Hicks, it is 204 feet. Along its outcrops it is a porous sandstone sometimes passing into a conglomerate, and where it has been penetrated by borings in the Dakotas it is very friable and open in structure. Its thickness, porosity, and extent, as well as its attitude, so far as is known are all in favor of its being an abundant source of artesian water.

The formations which occur in the general region under discussion, as given by F. V. Hayden, are as follows:

Thickness of strata above the Dakota sandstone.

Name.	Character of strata.	Thickness.
		Feet.
Loup River beds	Fine loose sand, with some layers of limestone	300-400
White River group	White and light drab clays, with some cavities of sandstone and local layers of limestone.	1,000
Wind River deposits	Exposed principally in Nebraska	1,500-2,000
"Fort Union," Laramie	Sandstone with shale	2,000-10,000
Fox Hill	Gray ferruginous and yellow sandstone and arenaceous clays.	500
Fort Pierre	Dark gray plastic clays above; dark beds of very fine unctuous clay, containing much carbonaceous matter with veins and seams of gypsum, etc., below.	700
Niobrara	Lead gray calcareous marls above; light yellowish and whitish limestones below.	200
Fort Benton	Dark gray laminated clays, sometimes alternating near the upper part with layers of light gray limestone.	800
Dakota	Yellowish, reddish, and occasionally white sandstone, with alternations of various colored clays and beds of lignite.	400

The surface throughout the region occupied by the Dakotas has been greatly eroded and it is not probable that the entire series as given above anywhere exists. It is to be expected also that the strata above the Dakota sandstone may be found of variable thickness and lithological character. These considerations as well as the secondary structure of the Great Plains would have to be investigated in order to predict

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for any locality at what depth the water-boring strata might be reached. Some of the wells in eastern Dakota derive their water supply from middle Cretaceous. The conditions to the west of where these wells are located seem equally favorable for obtaining flowing water from this horizon. It is to be expected, however, that water derived from these strata would be less pure than from the Dakota sandstone and consequently of doubtful value for irrigation. The Laramie may also be expected to yield artesian water.

Beneath the Dakota along the western outcrops there are shales and other impervious strata belonging to the Triassic system. It is to be expected that these coarse Triassic beds will carry water, but the great depth at which they occur underneath the Great Plains probably renders their consideration as a source of water supply necessary; besides, the Triassic strata are so highly charged with easily soluble salts that water derived from them would be too alkaline and saline for irrigation or domestic use.

NOTE.—These statements were made up in the U. S. Geological Survey by various geologists, gathered from many authorities, and presented by Director John W. Powell to the United States Senate Special Committee on Irrigation as his conclusions.

WELLS IN NEBRASKA.

Record has been found of but four artesian wells, one at St. Helena, a short distance below Yankton; one at Omaha; one at Lincoln, a mineral water; and one at Brownville, in Nemaha County, in the southeastern part of the State.

That at St. Helena derives its waters from the Dakota sandstones, at a depth of 400 feet, and in reality belongs to the system of South Dakota. The flow is copious.

The wells at Omaha, 750 feet, Lincoln, 985, and Brownville, 1,001 feet, derive their water from various strata in the Coal Measures. Of these the well at Omaha affords pure, fresh water. The Lincoln well yielded fresh water (not artesian) at a depth of 100 feet; a strong brine at 244 feet, the base of the Dakota, and medicinal water at 544 feet. The last is the water used. The flow is strong. Of the Brownville well no record of its water can be found.

These statements are made on Director Powell's authority. Professor Hicks, State geologist, says:

The artesian water of Nebraska is the best I ever saw. The belt runs somewhat west of north. That belt strikes Nebraska. In Knox County there is excellent artesian water to be found and at very moderate expense, but it is not in the belt that needs it. That artesian water is going to be of great value for power, if for nothing else. You can get a great water-power by boring into the earth. In the western region, where irrigation is most needed, the results of exploration for deep artesian waters have so far been negative.

AN ESTIMATE FROM COMPETENT AUTHORITY.

Capt. George M. Wheeler, E. C., U. S. A., retired, expressed the belief that of the reclaimable areas of this country 15 per cent. will be irrigated by artesian wells. He believes 200,000,000 acres can be reclaimed.

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The following table is the result of the observations of Geologists Mudge, Hay, and St. John, and of evidence taken before the United States Senate committee:

No.	Geological horizon.	Location.	Depth.	Caliber.	Delivery per minute.	Remarks.
			Feet.	*In.*	*Galls.*	
1	Tertiary	Edward's well, Meade Co.	155	....	36.00	Pure.
2	....do	.....do	165	....	32.4	Do.
3	....do	.....do	185	....	29.6	Do.
4	...do	Mart's well, Meade Co....	140	....	66.6	Do.
5	....do	Bower's well, Meade Co ..	125	....	37.3	Pure; waters rise 15-20 feet above surface. Temperature Meade Co. wells 69° F.
6	....do	Norman's well, Meade Co.	127	....	37.3	
7	....do	Cox well, Meade County..	175	..	9	Pure.
8	....do	.....do	142	....	9	Do.
9-68	....do	60 other wells, Meade Co..	50-175	....	1-30	Do.
69	Tertiary?	Norton, Norton County...	.....	....	.....	No data; may be Dakota; depends on depth.
70	....do	Hoxie, Sheridan County..	.....	....	.....	
71	Dakota	Smith Centre, Smith Co ..	.....	....	.....	No data; may be Tertiary; depends on depth.
72	....do	Great Spirit Spring, Mitchell County.	.....	....	.....	Natural artesian flow.
73	....do	Miltonvale, Cloud County.	.....	....	.....	No data as to water.
74	....do	Wa Keeney, Trego Co	.....	....	.....	Do.
75	....do	Hays City, Ellis County..	.....	....	.....	Do.
76	....do	Great Bend, Barton Co....	344	....	6.75	Saline; well bored to 1,400 feet, but water from 344 feet; rises 30 feet above surface.
77	....do	Kinsley, Edwards County.	.....	....	.....	No data as to water.
78	....do	Dodge City, Ford County.	.....	....	.....	Do.
79	....do	Santa Fé, Haskell County	.....	....	.....	Do.
80	...do	Ulysses, Grant County ...	.....	....	.....	Do.
81	....do	Opera House, Coolidge, Hamilton County,	239	....	45	Pure; water rises 15-20 feet above surface; now choked, owing to Opera-House fire. Temperature 61° F.
82	....do	Peck's well, Coolidge, Hamilton County.	298	6	100	Pure and medicinal; water rises 15-20 feet above surface; medicinal properties slight. Temperature 61° F.
83	....do	Border's well, near Coolidge, Hamilton County.	200	....	8	Pure; water rises 15-20 feet above surface; used for irrigation. Temperature 61° F.
84	....do	Burt's well, near Coolidge, Hamilton County.	275	....	35	Do.
85	....do	Nolan's well, near Coolidge, Hamilton County.	240	....	53	Do.
86	....do	Rich's well, near Coolidge, Hamilton County.	240	....	50	Do.
87	...do	Syracuse, Hamilton Co ...	1,000	....	.....	Water rose only to 90 feet below surface.
88	....do	Ashland, Clark County ...	.....	....	.....	No data as to water.
89	Triassic	Richfield, Morton County.	600	...	6.3	Pure and medicinal; mineralization slight. Temperature 66° F. Dakota furnished no flow; penetrated Trias 265 feet; water from 570 feet.
90	...do	Larned, Pawnee County ..	750	....	250	Saline and medicinal; water spouts 10-15 feet high. Temperature 65° F.
91	Carboniferous ..	Russell, Russell County...	977	....	Good .	Saline; may be Triassic.
92	....do	Winfield, Cowley County.	1,200	....	..do ...	Saline; rises 6 feet above surface.

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WELLS IN WESTERN TEXAS.

List of wells.

No.	Geological horizon.	Location.	Depth.	Caliber.	Delivery.	Remarks.
			Feet.	*In.*		
1	Tertiary	Carrizo Springs, Dimmit County.	175	4	Good	Pure.
2	Lower Cretaceous (probably Dakota)	Cotulla, La Salle County	1,008	....	do	Medicinal; jets above surface. 6 ft.; water alkaline-saline. Temperature 86° Fah.
3	do	San Antonio, Bexar Co	225	....	do	Pure.
4	do	San Antonio (near), Bexar County.	450	....	do	Pure and medicinal; could be used for medicinal purposes.
5	do	Dallas, Dallas County	750	....	do	Pure.
6	do	Fort Worth, Tarrant Co	350	....	do	Do.
7	do	Weatherford, Parker Co				No data as to water.
8	do	Canadian, Hemphill Co				
9	do	Tascosa, Oldham County				
10	do	Armstrong, Armstrong Co				
11	do	Mobeetie, Wheeler County				
12	do	Clarendon, Donley County				
13	do	Childress County				
14	do	Cottle County				
15	do	Floyd County				
16	do	Margaret, Hardeman Co				
17	do	Crosby County				
18	do	Pepper's Ranch, Kent Co				
19	do	Haskell, Haskell County				
20	do	Anson, Jones County				
21	do	Roby, Fisher County				
22	do	Snyder, Scurry County				
23	do	Dawson County				
24	do	Trent, Taylor County				
25	do	Sweet Water, Nolan County				
26	do	Colorado, Mitchell County				
27	do	Big Springs, Howard Co				
28	do	Marienfeld, Martin Co				
29	do	Midland, Midland County				
30	do	Glasscock County				
31	do	Coke County				
32	do	San Angelo, Tom Green County.				
33	do	Centralia, Tom Green Co				
34	do	Aroya, Ward County				
35	do	Toyah, Reeves County				
36	do	Wild Horse, El Paso Co				
37	Carboniferous	Wichita Falls, Wichita County.				
38	do	Archer, Archer County				
39	do	Henrietta, Clay County				
40	do	Montague, Montague Co				
41	do	Throckmorton, Throckmorton County.				
42	do	Jacksborough, Jack Co				
43	do	Palo Pinto, Palo Pinto Co				
44	do	do				
45	do	Albany, Shackelford Co				
46	do	Abilene, Taylor County				
47	do	Tebo, Taylor County				
48	do	Baird, Callahan County				
49	do	Eastland, Eastland Co				
50	do	Eastland County				
51	do	do				
52	do	Stephenville, Erath Co				
53	do	Comanche, Comanche Co				
54	do	Coleman, Coleman Co				
55	do	do				
56	do	Runnels, Runnels Co				
57	do	San Saba, San Saba Co				

Mr. Frank E. Roesler, of Dallas, Tex., who has devoted much time and study to questions involved in the economic uses of well-water, especially in irrigation, describes as follows the water supply by wells of the Staked Plains region:

The "underground water" is generally found at varying depth. At Marienfeld, on the eastern edge of the plain, at from 60 to 90 feet; at Germania, 10 miles west, at 45

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to 60 feet; at Midland, 20 miles west, at 35 to 50 feet; at Odessa, 40 miles west, at 30 to 60 feet; at Douro, near western edge of the plain, none. In a few localities "joint clay," a water-proof material, on which the "underground" water rests, comes close to the surface. No water was found, though this material has often been penetrated to the depth of 500 feet. A few of the surface wells are brackish and several salty, but generally the water is good. Several springs containing soda, sulphur, or gypsum water, as well as a few wet weather salt lakes, are also found on the plain. The only permanent running stream on the Staked Plain is "Running Water," in Dickens County, a bright, sparkling stream that suddenly breaks out of the ground, ripples over a pebbly bottom for a distance of 10 miles, and then mysteriously disappears, like many other streams west of the Pecos River, notably Leon Wells, Comanche Springs, Escondido, Limpia, and Toyah Creek, or the underground river near Castle Mountain, in Crane County, which is working its way to daylight by washing away the roof covering it, occasionally causing a part of it to fall in. A similar stream exists in the northern part of Crocket County, which was not known to exist a few years ago, though a recent cave in exposed an abundant water supply 20 feet below the surface.

Nearly all the wells dug or bored in the "underground" water, under the limestone, show a tendency to rise above the point where the water was first reached. In some localities a rise of 20 to 30 feet was observed, showing that the supply is under considerable pressure. Borings at Odessa have shown five separate layers or deposits of water to exist between the surface and the "joint clay" 100 feet below. Between the Staked Plain and the Pecos River is an ancient fresh-water lake basin, known as the "White Sand Hills," which is covered with numerous ponds of pure fresh water. The supply is permanent, and said to be inexhaustible. The railway wells at Monahans, in this locality, furnish an immense supply. Altitude, 2,620 feet. The wells west of this and to the Pecos draw their supply from the seepage of the Pecos River. East of the Staked Plain the water supply in wells is variable as to quantity, quality, and depth. In Howard County good water is abundant in the southern part, rather deep in the northern part, and brackish in the town of Big Spring. In Mitchell County generally good at 30 to 50 feet, sometimes strongly alkaline. Several wells bored are capable of furnishing 9,000 gallons of water per hour continuously. At a depth of 200 to 300 feet super-saturated salt brine, claimed to be chemically pure, is found in inexhaustible quantity, and a fine grade of salt is manufactured. The Colorado River carries water in its bed nearly all year round. Its water here is said to be brackish and salty. A chemical examination will have to determine whether or not the water can be used for purposes of irrigation.

THE STAKED PLAINS.

Mr. Roesler gives in this connection some data bearing on the practical use of wells:

On the Staked Plain but very little water will be needed, but when needed is needed badly. Continuous irrigation is not required. In the history of every crop there is a critical moment in which it is determined whether or not the farmer shall have a full crop, a half crop, or a failure. A rain-fall to-day makes his crop, a rain-fall two weeks hence does him no good. One or two, or possibly three, irrigations during the year, each equaling a two-inch rain-fall, would bring him a great harvest. More than that he will hardly need. In 1888 and 1889 he made a full crop without irrigation; in 1886 and 1887 he did not get his seed back, though the rain-fall of each year, if properly distributed, would have made splendid crops.

The acreage that can be irrigated from a 6-inch bored well in a dry year by using a 10-foot windmill will be about five acres; varying with the rain-fall. By the use of a suitable storage-tank the capacity of the plant may possibly be doubled, but at all events the acreage irrigated is very small compared with the cost of the outfit, which runs between $200 and $350. Five acres under irrigation by a $200 plant will cost the owner $40 per acre, and if he borrows the money, paying 10 per cent. interest, he practically pays a water rent of $4 per annum.

This expense is for water alone. If the farmer plants trees and grape-vines he must have rabbit-proof fencing, which may cost him $10 per acre additional. Comparatively few new settlers will be financially able to incur such expense as is necessary for a good water plant, and if they do succeed in securing their water supply it will be at such cost per acre that very high-priced crops must be grown and successfully marketed to meet the interest on the investment to be profitable. The raising of the cereals and forage crops by irrigation will, therefore, be entirely out of the question, but if the cost of the water supply can be reduced, the growing of early vegetables, fine table grapes, early fruits, raisins, prunes, and the making of wine can be made profitable.

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The estimates on a section of land near Mildland or Odessa, where the presence of water in sufficient quantity has been determined by previous tests, are given as follows:

640 acres of land, at $3 per acre	$1,920.00
704 fence posts, at 15 cents	105.60
1,408 stays 1 x 6 (704 feet of lumber)	35.00
7,200 pounds Glidden barbed wire, at 5½ cents	396.00
21,220 feet 30-inch netting, 1½ inch mesh, No. 19 wire	462.00
Freight on same	50.00
4 gates, staples, hardware	75.00
30 adobe or box houses, at $150 each	4,500.00
27,040 young fruit trees and freight, at 10 cents, for 160 acres	2,704.00
64,000 young rooted grape-vines, at 5 cents, for 160 acres	3,200.00
Office of superintendent	250.00
Salary of superintendent three years, at $720	2,160.00
Wages, five farm laborers two years of three hundred days, at $1.25 per day	3,750.00
Surveying, freights, commissions, advertising, etc	2,200.00
Farming implements, live-stock, etc	500.00
	22,307.60

The total cost of improvement per acre will be $34.85, or $22,307.60 for the section. All of the land is put in tillable condition, but only one-half is planted in trees and vines. There is a delightful uncertainty as to quantity of water obtainable, size and capacity of wells, windmills, and storage tanks required. The estimate will vary with each section of land used, The estimate on a certain section of land which the writer has in mind is as follows:

Seven dug wells, tunneled in water-bearing strata, at $1,200	$8,400
Seven 30-foot windmills, pumps, towers, etc., at $700	4,900
Ten storage tanks, at $350	3,500
Six miles of wooden flumes, etc.; 95,000 feet lumber, at $25	2,500
	19,300

An average cost of $31.10 per acre for water. Adding together the cost of the improvements, $22,307.60, and the cost of water supply, $19,300, we have a total cost of $41,607.60, or $65.01 per acre.

WELLS IN THE NORTHWEST.

At Miles City, Mont., fourteen artesian wells have been successfully bored. The depth is from 535 feet or less. The average bore is 4 inches. On the other side of the Yellowstone River a flowing well was obtained at 50 feet, the elevation being 600 feet above the river. The water in these wells is chiefly used for garden irrigation and domestic uses. At Helena the city is supplied from deep artesian wells. In the vicinity, however, artesian water has been obtained at a depth of 160 feet. It yields 200 gallons per minute, is of good, clear character, and is used for irrigation to a limited extent. At Billings a well over 1,000 feet in depth is in operation.

Artesian water has been found and utilized by wells at Oxford, Boise City, Idaho, Pasco and Roslyn in Washington, and at Warm Springs, Oregon.

WELLS IN UTAH.

This Territory furnishes some valuable evidence of the use of artesian and flowing wells in agricultural operations, but it is stated by experts that such evidence is overestimated. The wells so far found are in some one of the basins of the ancient lake of which Great Salt Lake is the present remainder. In his official report to the Senate committee, Governor Thomas said:

The clay sediment from that lake makes the impervious cap of those subterranean reservoirs, whose rims are but slightly elevated above the villages, and the reservoirs are fed from the bases of the mountains where the surface water runs over the gravel débris between the mountains and the clay rim. The average depth of these arte-

sian wells in Salt Lake Valley is about 100 feet, in Utah Valley 200, and in Tooele about the same. In Millard County a few wells have been driven with a depth of about 200 feet and a flow of one-half to 10 gallons per minute through 1¼ inch pipe. Since no solid rock is struck in driving these wells they are very liable to clog up in a few years. The flow in Salt Lake Valley will not average 25 gallons per minute, though some wells far exceed that. A well flowing 5 gallons per minute will irrigate an acre of ground.

Utah County reported that artesian water can be had for all the land on the west side of the valley. Prof. M. E. Jones does not think that the Utah wells are of true artesian character. He said:

In Utah it is very different. The artesian wells or basins are very large, some of them occupying, perhaps, 100 square miles; but the water is obtainable only around on the edge, and when you get out to the middle of the valley, you are so far away from the source of the supply that you will get only about half a gallon a minute, which is only enough for drinking purposes. We can not, therefore, depend on artesian wells in this vicinity for an increase of our water supply.

There are over five thousand of the small artesian or surface-flowing wells in the Territory. Certainly 20,000 acres are now irrigated by them.

WELLS IN NEVADA.

The State claims a considerable area of artesian waters. From a report made by the State board of reclamation, after a reference to the large number of mineral springs in the State, the following is quoted:

Nevada occupies a prominent place as a mineral-spring State; both hot and cold springs are found in every county. The warm and hot springs are found mainly in connection with geological fault-lines or fractures of the strata. Can we not, from these facts, reasonably conclude that the sinking of artesian wells would not only be advisable, but that the probabilities of obtaining large streams of water therefrom are great?

There were, in 1888, sixty-five wells sunk in our State, ranging in depth from 109 to 310 feet, twenty-five of which were 6 inches in diameter, averaging in flow about 20 gallons per minute.

The others have a diameter of 3 and 4 inches, and vary in flow from 11½ to 33 gallons per minute.

[From surveyor-general's report, 1887-'88.]

County.	Artesian wells—1888.			
	Number.	Depth.	Size of pipe.	Flowing capacity 24 hours.
		Feet.	*Inches.*	*Gallons.*
Churchill	2	1 300 1..2, 100	4	2,000
Douglas	2	1....225 1....310	3	43,200
Elko				
Esmeralda	1			
Humboldt				
Lander	25	150 to 200	6	*28,800
Lincoln				
Lyon				
Nye				
Ormsby	35	1....109 1....150 1....138	3	48,960 15,000 15,000

*Average.

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Three counties, Storey, White Pine, and Washoe, have no wells to report. It is claimed that the following areas are underlaid with artesian water, which may be made available for irrigation:

County.	Valley.	Square miles.
Eureka	Diamond	500
	Grubb, Monitor, and Antelope	500
White Pine	Newark	200
Nye	Pahrimp	1,750
		2,950

That is, a total of 1,888,000 acres. The number of springs (mineral) reported in Nevada is 115. There are also a large number of non-mineralized springs, some of which are of large size. One is reported, the water from which irrigates 2,500 acres of land.

IN CALIFORNIA.

A large number of artesian and flowing wells are developed in this State, and they are extensively used in agriculture and horticulture for irrigation. The wells whose waters rise to the surface, flowing probably from the primary and secondary water beds, are very numerous in the foot-hills, central valley, and bay regions of the State. They irrigate all gardens and considerable areas of orchard. In the coast counties south of San Francisco such wells are common; their sources being everywhere accessible. In the eastern sections or rims of the San Joaquin, San Fernando, San Bernardino, and other valleys, on the Mohave Desert, and along the edge of the Colorado Desert, artesian and flowing water belts have been extensively developed. Some of them are of large extent and considerable volume. In Tulare and Kern Counties there are large districts supplied entirely by artesian water. Some of the wells are of great volume. One at Delano, Kern County, for example, is reported as capable of irrigating for alfalfa and grain some 20,000 acres. Used for fruit land, then, the duty would be nearly double.

In the San Fernando Basin, in both Los Angeles and San Bernardino Counties there are already nearly two hundred wells developed for irrigation use. They play an important part in Riverside and its related colonies; at Chino, where 20,000 acres are irrigated by them; at Romona, Cucamonga, Temescal, Vivienda, and in fact are found in all the irrigated areas, colony lands, ranches, or small holdings.

The San Bernardino Basin is important as a well region, over five hundred being made use of for irrigation purposes. At Old Riverside* there are fifteen wells in use, flowing 300 miner's inches a second. An average flow of 20 miner's inches per second is sufficient for 1 acre.

*THE SAN BERNARDINO BASIN.

[From Hall's Irrigation in Southern California.]

The water supply for the pipe-line works is derived and expected to be derived from artesian wells in the San Bernardino basin, at a point three quarters of a mile south of the river bank, and about 1½ miles east of Warm Creek mouth. The ground elevation here is about 995 feet above the sea, about 115 feet above the highest point in, and 180 feet above the general elevation of the central portion of Riverside town. Here on a plat of 7½ acres, just within the recognized lower limit of the artesian basin, and near to the famous Hunt artesian spring, seven artesian wells, each 11 inches in diameter, have been bored, six of them to depths varying from 111 to 120 feet, and one to a depth of 215 feet. Their flow ranges from 18 to 28 miner's inches to the well, and the total supply is 163 miner's inches. The work of boring other wells is in prog-

The average flow per well in this basin has been estimated at over 47 such inches, making a service of 2½ acres per well. With the careful economy of water now practiced by small storage tanks and pipe distribution it is quite certain that the area of duty may be easily doubled. The one thousand artesian wells now flowing in southern California will therefore have an irrigated service of at least 5,000 acres. A curious fact has been developed, showing the dependence on the mountain drainage of the arterial veins and basins. The seasonal ebb and flow of volume in these wells is quite regular and marked in amount. Ex-State Engineer Hall thus describes the artesian supplies of the region:

ITS RAINFALL AND ARTERIAL DRAINAGE.

It is a known fact that along the upper edge of the plain—at Highlands, near the extreme eastern end of the valley, at Etiwanda farther west, and other places, where observations have been made—the rainfall is about double that which is found on the plains but a few miles away. And so, precipitation is not here affected so much by altitude as by the presence of the wall-like mass of mountains which obstructs the movements of the clouds, and holds them until they bank up to the point of releasing their vapors.

Speaking now only of that portion of the mountains within San Bernardino County, with the exception of the region lying on the sides of San Bernardino peak and Grayback, drained respectively by Mill Creek and the Santa Ana River, and the region out of which comes Lytle Creek, all of the mountain catchment areas are such as shed their waters with remarkable promptitude. The drain slopes are exceedingly steep, oftentimes, in the main cañons even, 200 to 300 feet per mile; and on the southern face of the range, although in the cañons there is a wooded growth, those accumulations of vegetable molds and soils which are recognized as holding waters, and giving them out in the form of surface drainages, are limited in extent.

At some time, in the geological history of this country, it has been subjected to an immensely greater rainfall than it receives at present; such that enormous torrents, comparatively speaking, have come out of these mountain cañons, and piled great masses of bowlders and gravels before them. The principal streams have built veritable ridges far out into the plain in front of their cañon mouths, which slope not only forward, but sideways; and looking at the base of the mountain across the valley from south to north, one sees the profile of the plain as it rests against the mountain's base, with hills out upon which the streams come, and valleys in between. The heads of these ridges, next the cañons are, of course, composed of specially permeable detritus, which extends up into the cañons, filling the deep bed-rock cuttings with

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ress, and it is intended to continue it until a flow exceeding 225 miner's inches is secured. The wells are located at 50-foot spaces in two diverging lines 50 to 200 feet apart. Their waters, received into a little cement basin around each well, are collected by means of small flumes into a shallow, masonry-lined, circular reservoir 30 feet in diameter, across which is an overflow weir, and over this the water drops in a thin sheet, thus becoming somewhat aerated before entering the pipe.

Summary.

Group.	No.	Diameter.	Average depth.	Flow.
		Inches.	*Feet.*	*Miner's inches.*
A	2	7	110	135
B	6	7	150	256
C	4	7	150	44
D	4	10	226	329
	16	.....	.....	764
Scattered	4	7	.....	60
Hunt	9	7	115	130
	29	.....	.....	954

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masses of broken matter, ranging from sand grains up to rocks of many tons weight. Into such beds a large portion of the waters of these streams sink, and percolating through the interstices, and running through the openings in the débris, find entrance into the old channels of former streams in the permeable layers under the plain, long since closed over by layers of material less permeable and which have become closely cemented. Such is the source of artesian waters which are found to rise in the bottoms of the basins throughout the country. The San Bernardino valley, or basin as we have called it, is a very well marked formation of this class. Again, the land at the foot of the great Cucamonga plain and resting against the Coast Range, which is herein called the Rincon basin, is another such formation.

Into the San Bernardino basin from the west a part of the waters of Lytle Creek find passage through gravels, which it has deposited in channels here and there at different periods in its existence, and which are more or less permeable. A large part of those of the Cajon pass stream sink farther up, and find their lodgment also in the artesian strata of this basin. From the east the Santa Ana river comes through a wide cañon, filled, no one knows how deep, with such débris; and a share of its waters contribute also by this means to the artesian supply. While the streams like City Creek, Twin Creeks, Devil's Cañon, and others, which come to the valley at its northern edge, seldom ever course beyond a few hundred yards into the plain, and there sink to the same great receptacle—the subterranean gravel-filled channels.

The artesian basin of the Rincon and Chino is fed by the sinking waters of San Antonio, Cucamonga, and other cañons which run into the upper edge of the Cucamonga plain, 10 miles or more away, and 1,000 feet higher. While the uprising of waters in the neighborhood of Pomona is but their liberation from some old channels and beds of San Antonio Creek on their way down under the plain towards the Rincon.

The arterial drainage of this whole country is one everywhere complicated by the artesian feature thus outlined. The Santa Ana River sinks and rises, and sinks again rapidly in its course, and receives tributaries under ground, so that it would be difficult to identify waters rising below with those which have sunk at any specified locality above. It is the main drainage way of all this country, however, and the entire arterial drainage output of the great San Bernardino Valley, speaking now of the whole region which has just been described, and not of San Bernardino basin alone, is probably by way of the Santa Ana Cañon above or beneath its sands, through the Coast Range.

IN SAN DIEGO COUNTY.

The Upper San Jacinto Valley, in San Diego County, is the only basin explored. The limits of the artesian belt have been well defined by borings, and comprise about 10,000 acres. There are now one hundred and nine flowing wells, and as yet the flow of existing wells has been slightly, if at all, affected by the new ones:

The characteristics of all the artesian basins of southern California are here reproduced. The water-bearing strata are six or more in number, and lie at a depth of from 12 to 500 feet below the surface. They are not uniformly distributed over the area of the belt; that is to say, they apparently follow old river channels, whose courses are not clearly traced out, and there is a measure of uncertainty in boring a well as to which of the water-bearing strata will be encountered. The generality of the wells bored are about 200 feet in depth. Some of them have the strong flow of 20 to 50 miner's inches. The head of pressure forces the water to heights varying from 5 to 18 feet from the surface, and it is customary to control the flow by extending the casing or pipe a short distance higher than the water will rise, and tap it again when the water is required by a valve on the side near the surface, a convenient arrangement. Attempts have been made to strike flowing water on the Lower San Jacinto plains, at various places, without success.

IN COLORADO.

A very marked artesian basin is that of which Denver is the center. There are about four hundred wells within its limits, of which about sixty are returned as used in irrigation service. The area under them is unreported at present, but it is known to be of considerable extent. Other development is in progress in the State.

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IN WYOMING.

On Laramie Plains, artesian water has been struck. Some thirty wells are developed. There are other developments under way and great hopes are entertained of the future economic value of artesian water in this State.

No such development has yet been had in New Mexico and Arizona, yet the indications are excellent.

THE USE OF WELL WATERS.

Prof. George E. Culver, of the State University, Vermillion, S. Dak., who serves the United States artesian well investigation as its Dakota geologist, has made some calculations of value in relation to the use of water in irrigation, which are given here:

One inch of rainfall gives 860 barrels to the acre.
One inch of rainfall gives 550,400 barrels to the section.
One inch of rainfall gives 19,814,000 barrels to the township.
The average rainfall of the Missouri valley is about 20 inches, probably a little more in the region under discussion. Multiplying the number in the above table by 20, we have the following results:
Twenty inches of rainfall gives 17,200 barrels to the acre.
Twenty inches of rainfall gives 1,100,800 barrels to the section.
Twenty inches of rainfall gives 39,628,800 barrels to the township.
Suppose it is desirable to double this amount by means of wells, and suppose a well flowing 100 barrels a minute be taken as a standard. Such a well furnishes:
One hundred barrels a minute, 6,000 barrels an hour, 144,000 barrels per day, 52,560,000 barrels per year.
Making the division, we find that it would require seven such wells in each township, provided that all the water is used in the township, none escaping to the lower levels. It is not probable that this latter would be true. Nor is it believed that it would be necessary to double the present rainfall. One-half that amount under control would be ample.

Director Powell, of the U. S. Geological Survey, presented to the Senate Committee on Irrigation, in offering data as to wells already quoted, the following views:

ECONOMIC LIMITATION ACCORDING TO DIRECTOR POWELL.

Artesian reservoirs can never furnish waters for agriculture on a scale of sufficient magnitude to be considered as an important source of supply. The amount of waters which porous rocks will supply is always very insignificant compared with the amount necessary for irrigating any great tract of land. More than half the agriculture of the world is dependent on irrigation. Of this, a very insignificant amount depends on artesian wells. There are wells here and there in Europe, Asia, Africa, and America, and in some of the great islands, but altogether they furnish a very small amount of water for agriculture. If all the artesian wells used for irrigation in the world were assembled in Dakota they would not irrigate a county of land. But there are other serious reasons why the attention of the people of the great plains should not be directed too confidently to this resource. It is the experience with artesian wells everywhere throughout the world that if too many are bored in any basin all are destroyed thereby. In the northern Illinois district, it was hoped that the great city of Chicago could be supplied with water for domestic purposes by artesian wells, but experimentation proved that, while a few good wells could be secured, a great number was impossible; that the supply of water would be absolutely inadequate for the wants of the city; and so the authorities were compelled to resort to the lake for their supply. Now, to irrigate the site of the city of Chicago would take more water than to supply it for domestic purposes; so that the artesian wells of that district would be entirely inadequate to irrigate an area as large as the city, or perhaps one-fifth or even one-tenth of the area. Some years ago it was pointed out that the city of Denver and the region round about was the site of an artesian basin. The first well site proved to be very valuable, and the desire to secure water for domestic purposes therefrom led to their multiplication. More than three hundred have now been bored, and gradually with the progress of the boring the collapse of the wells has resulted, and now all the wells have to pumped; there is little or no flowing water from them. These instances might be multiplied all over the world, and the experience of mankind entirely testifies that it would be unwise to encourage

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the people of any district of country to depend upon artesian waters for irrigation on any large scale for farming. Waters for domestic purposes, for irrigating gardens, and for supplying stock ranches may thus be obtained in many regions, and the supply of water that can thus be furnished is of value; but when considered as a source for agriculture, for the cultivation of fields and large tracts of country, it will always be inadequate; and it is unwise to encourage any people to engage in agriculture on a large scale and depend on irrigation from artesian wells.

For the district of which I am now speaking, extending from the British to the Mexican line in a broad belt across the plains on both sides of the hundredth meridian, the people will ultimately be compelled to depend upon another source of supply, and one so important that in comparison therewith the artesian supply sinks into insignificance and seems hardly to be worthy the mention. I refer to the use of the storm waters. One-third of the agriculture carried on by irrigation throughout the world is prosecuted by the storage and use of storm waters, and the experience of mankind in this respect is replete with lessons that can not be neglected. The region to which this is especially applicable is the subhumid region. It differs from what I have called the arid region in that it generally has a greater rain-fall, distributed more evenly over the country, as it is not interrupted by great mountains where the precipitation is concentrated, having from 15 to 22 inches of rain-fall in the average year; sometimes more, sometimes less. There are many years when agriculture is prosperous without irrigation; there are others when it fails without an artificial supply of water. Gradually with the progress of agricultural development it is possible to cover the country with storage basins, or tanks as they are usually termed, in which water may be held to be used in seasons of drought. By this means the farmers may be able to tide over the dry years, and farming may be made prosperous and highly remunerative thereby from year to year. It is in this direction that the attention of the people of that region should be turned. There is another source of water for that country of far greater importance than that of artesian fountains, but far less than that of the storm waters. I refer to sand reservoirs along the channels of the streams, especially of the great rivers. In that region of country the stream valleys are often great beds of sand, into which sinks the water which comes from the distant mountains, and into which sink the storm waters that come from the adjacent hills. Experience in other countries shows that this source of supply is worthy of consideration, and the experiments now in progress in the Arkansas Valley give indications of like character.

REASON FOR AN INQUIRY.

The need is imperative and the investigation one that should be carried on even if appropriations are not made for the full topographical-geological surveys alleged to be so absolutely necessary. There is an immense area under cultivation in the arid sections of the world, the waters for fructifying which are drawn from wells and painfully distributed by the most primitive use of man and animal power. It has been estimated that in British India alone 20,000 wells are used for agricultural irrigation. An estimate has been made that the areas so watered support at least twenty million persons. Ceylon, Japan, China, Persia, all settled portions of Central Asia, the entire plateau region of Arabia (in which there is not a single surface stream and on which several millions live, in comparative prosperity for an Asiatic people), Syria, large portions of northern Africa, from Egypt to Morocco, are all largely irrigated by water supplies drawn from wells. It is a subject that has never been investigated, but even a cursory examination will satisfy an inquirer that at least fifty million persons are supported from agriculture carried on by means of the use of wells in irrigation.

It is quite certain that there is no occasion to dogmatize in advance of systematic examination for or against the economic value in arid agriculture of wells and underflow waters, artesian or otherwise.

THE STORAGE OF WATER.

The engineering questions involved in the distribution of the waters "in sight," in the preparation for and process of storing and impounding of the high altitude supplies—snow, storm, and torrential—now largely lost in the ground, and in the subsequent distribution are not so in-

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volved and "scientific" in character that the "plain" people may not understand them when properly informed.

In regard to high altitude work it must be borne in mind that what we now really know of the precipitation over the whole of this region relates more to the valleys and the table-land than to any other part. All meteorological or weather service reports have been simply for the purposes of local trade and traffic. We have had no system of observations of a definite and distinct character in regard to the mountain ranges. The rain chart presented in the last census by Mr. Gannet, and which has been improved by later observations, shows the only record that of rain-fall definitely from the ninety-eighth degree to the Pacific Ocean will range from 3½ inches at certain points, as at Yuma and on the Colorado Desert, or going from the east to the west, from 20 inches down to 8 and 9 in the basin, and up again to 18 and 20 or 24 on the Pacific coast. It is known as a matter of fact, though not as a recorded series of observations, that the rain-fall and snow precipitation on the mountains is from 30 to 60 inches in excess of what it is in the valleys below. The average snow-fall on the Sierras will be from 60 to 70 feet of loose snow, giving us on the basis of 11 inches of snow to 1 of water from 5 to 6 cubic feet of water. All, or nearly all, of this water runs to waste. At least 40 per cent. of it passes away in evaporation, and the remainder into the ground. Probably the largest portion disappears below.

The United States Irrigation Survey reports up to the close of 1889 the storage capacity of reservoir sites so far surveyed to be as follows:

Locality.	Capacity.	Delivery.
	Acre-feet.	*Acre-feet.*
Colorado	228,200	334,200
California	445,000	55,000
Idaho and western Wyoming	1,500,000	3,220,000
Montana	715,500	2,165,500
Utah	62,800	56,300
Total	2,951,500	5,831,000

From the statement made before the Senate committee by the Director of the Geological Survey of the total amount of lands "selected" as irrigable in the following States and Territories, the following figures (in acres) are given:

Montana	11,500,000	
Idaho	10,900,000	
Utah	2,200,000	
		24,600,000
"Segregated" as irrigable:		
California	1,800,000	
New Mexico, on the Rio Grande and Rio Grande Valley	5,200,000	
		7,000,000
Total		31,600,000

FOREST TREES AND THEIR CONSERVATION.

The subject of forestry is a part of the investigation of the question of the irrigation of the arid region and its importance can not be overrated, for "it is the discovery of a new continent, by knowledge, skill, science, and art." Possessing 75,000,000 acres of forests, little or no attention has been paid to the subject until very lately, and that only tentatively, by Congress. Our forests are wasted by fire and neglect, which by a judicious and economical management could be conserved and in-

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creased, and by their conservation and increase humidity will follow with new areas of rain. Trees act as a protection from the dry winds, and when planted and cultivated in narrow belts of timber shelter the crop from the wind-break and lower the rate of evaporation.

The following table, condensed from the report of Mr. B. E. Fernow, chief of forestry division in the Department of Agriculture, approximates the ratio of mountain land and plains and gives the forest area:

Rocky Mountain region.

	Area.	Mountain.	Plains.	Total forest.	Mountain forest.
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
Montana	145,776	54,776	91,000	26,285	24,810
Colorado	100,200	61,129	39,070	16,625	15,400
Wyoming	100,366	78,466	21,900	12,060	11,580
New Mexico	122,500	75,510	46,990	12,500	8,285
	468,842	269,881	198,960	67,470	60,075

SUMMARY.

	Square miles.	Acres.
Total mountain forest	60,075	38,448,000
	67,470	43,180,800
Total forest	198,960	127,334,400
	269,881	172,723,840
	468,842	300,058,880

Mountain forests equal 22.23 per cent. of mountain area.

Mountain forests equal 92 per cent. of total forest.

Little has been done in forestry planting. From the same report of the chief of the forestry division the following condensed statement shows the number of entries under the timber-culture:

Total number of acres entered from 1873 to 1888, inclusive 38,958,558.45
Total number of acres entered from 1873 to 1888, inclusive, final proof and entry could have been made in 1888 or earlier 9,346,661.03
Total number of acres on which final proof was made, or 8 per cent. of possible number 784,037.23
Total number of acres planted ..... 784,037÷16=49,002
Total number of trees declared to have been planted and cultivated ..... 38,076,350 or less than one tree for each acre entered for timber culture.

The valuable report of B. E. Fernow, chief of forestry division of the Department of Agriculture, bristles with facts upon this most important subject, the handmaid of practical irrigation.

The intimate relation of the forests to the water supply necessary for irrigation will soon force itself upon the consideration of those living in the Rocky Mountain region, and it is well set forth in a recent statement of Mr. Nettleton, State engineer of Colorado, who says:

It is estimated that 60 inches of water fall annually on the eastern slope of the Rocky Mountains in the form of snow and rain; 80 per cent. of this falls during the winter and spring months. That which falls late in the autumn and early in winter is most available for irrigation, as it becomes solid, almost like ice, and melts slowly under the summer's sun, affording a steady flow through the irrigating season. Snows falling in late spring melt rapidly, and the waters run down the rivers unused. Although about fifty mountain peaks in Colorado reach an elevation of over 14,000 feet, yet the snow nearly all disappears every season, small quantities only remaining in

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small patches here and there. On this account there are at present no glaciers in the Rocky Mountains. The cold mountains condense the moisture in the country adjacent, thereby robbing the plains of their quota of moisture.

Hence the necessity for irrigation. It is quite easy to foretell the probable amount of water for irrigation purposes for the coming season by watching the amount of snow-fall in the mountains.

Farmers living from 20 to 30 miles from the mountains, or where they can watch the snow-fall on the main range of the mountains, have learned to gauge their crops by the time the snow falls and the quantity. If the snow falls early, they expect water for late crops. If the snow falls principally in the spring months, they fear short water in summer and fall, and plant or sow accordingly.

There can be no doubt about the influence that cutting or burning the timber on the mountains has on the flow of our streams. They will on this account become more intermittent in their flow, which is a drawback to the irrigation interests of the State. The preservation of the mountain forests should be encouraged.

To sum up simply, then; the questions concerned and issues involved in the reclamation of our arid West, may be stated in the following propositions:

First. The use of the rain-fall in what are properly known as rain belts, by the most effective methods of cultivation, and the selection of suitable plants, especially those with long tap roots.

Second. The exhaustion of the supply furnished by rivers and creeks in their passage through the drains, by means of irrigation works, such as are already in extensive use. Most of our streams can be used up to the full amount of their annual discharge.

Third. The enlargement of the existing supply by the storage at higher elevations of water which passes away in spring floods. The building of numerous catch-basins throughout the plains to save the rain-fall which is wasted, so far as the lands near by are concerned, will add greatly in the supply furnished by running streams. There are natural depressions everywhere which can be utilized at very slight cost, and with entire immunity from risks of dangerous floods. Congress has already surveys to ascertain the most available sites and methods for accomplishing this plan.

Fourth. The sinking of galleries or tunnels below the surface of streams, even when they are practically dry, and utilizing by canals the underground currents. Pure filtered water at Cheyenne, Wyo., for the supply of the city, without pumping or much expense, is so furnished from a small stream nearly dry in summer. The utilization of surface water does not exhaust the supply for irrigation. The application involves waste. The fugitive waters sinking into the ground pass into the depressions which make the water-ways, and gradually swell the scanty streams at lower levels, or course their way toward the sea through the sands below the river beds. Thus a part of the water of irrigation canals is gathered a second time to do the work of irrigation.

Fifth. By the use of stationary pumps of sufficient power, in lifting such underground currents to the surface from bed-rock, for application to surrounding lands.

Sixth. By artesian wells, which have hitherto proved too expensive for use in irrigation.

To these six may be added the small storage or farm tank system, which can be effectually utilized on our plains region.

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IRRIGATION CONSTRUCTION.

ITS PLANS, PROJECTS, SYSTEMS, WORKS, FORMS, CONTRACTS, AND MANAGEMENT, PRESENT AND PROSPECTIVE.

PART III.

PROJECT FOR A DAM ON SALT RIVER, ARIZONA.

Mr. Wm. M. Breckenridge, county surveyor of Maricopa, presented a plan to the Senate Committee. He said the location settled on is at the mouth of Tonto Creek, a little above the mouth of Mazatzan Cañon. Mazatzal range cuts through the Upper Salt River. It makes a big cañon, with mountains on each side 1,500 feet high. The slope is one to one; that is, perpendicular for 100 feet. The water is thrown back eastward 16 miles on the Salt River, where it boxes again in the Sierra Ancha. For the first 2 miles from the mouth of Tonto Creek, point of construction already suggested, the average width is 2,640 feet, and the average depth would be 180 feet, calling the proposed dam 280 feet high. The next 2½ miles opens out into a valley, the average width being 2 miles and depth 140 feet. The river then narrows up at Steamboat Rock, 4½ miles above, so that it is only a quarter of a mile wide, with an average anticipated depth of 130 feet. Then above the Steamboat Rock passage for the next 10½ miles the average width is 2 miles, and the average depth will be 70 feet. Tonto Creek, with a width of 1¼ miles, could be made to obtain an average depth of 80 feet. There is ample space at a box cañon coming in from the south, where a waste-weir could be built, so that the river, when it arrived at a certain height, might run over that and not into the dam. By it, enough water can be stored to reclaim all the desert mesa land lying north of the Gila River between Phœnix and the Colorado River at Yuma. Sufficient quantities of water annually flow through the Salt River to fill this reservoir several times. It is our belief also that, by the selection of suitable reservoir sites along the Gila, water enough can be stored to reclaim all the lands south thereof in this county. The Agua Fria, where it enters the Salt River Valley, in the dryest season carries a stream of several thousand inches of water. If properly utilized there is sufficient in this river to irrigate all the land, some 75,000 acres, lying between it and Cave Creek, and by a reservoir the land could be made available.

THE PROPOSED PANTANO RESERVOIRS.

Engineer F. W. Oury, of Tucson, Ariz., outlines an extensive project for dams, reservoir, and diverting, at a point on the Southern Pacific Railroad, a few miles from Tucson. He says:

Location.—The sites for the proposed dams are located on the water-course commonly known as the Pantano Wash. Dam No. 1 is situated at the junction of the Cienega and Davidson's Cañon, about 23 miles southeast of the city of Tucson, where

still stand the ruins of the Cienega station on the old overland stage route. About 5 miles down the cañon, where the Southern Pacific Railroad track leaves the edge of the wash to go onto the mesa, is the site for Dam No. 2. Dam No. 3 is still farther down, about 2 miles from the preceding one.

Water supply.—Water runs throughout the year as far down as Dam No. 2, but in such small quantities as not to be a very important factor as a source of supply. Hence, it must depend on the freshets which come along this water-course, caused by the rain-fall over the country which it drains and which occur during the rainy seasons, summer and winter.

Drainage.—The Pantano Wash rises in a range of low mountains about 50 miles southeast of Tucson, known as the "Canelas," and runs, with innumerable bends and crooks, in a northwesterly direction, until it empties, near Fort Lowell, into the Rillito Creek; thence westerly until it reaches the Santa Cruz River. It thus drains a portion of all the mountains in eastern and southeastern Pima County, with the exception of the Patagonias. We shall refer, however, only to that portion of the water-shed, the water from which flows into the Pantano Wash above the points selected as sites for dams.

Reservoir sites.—In examining the San Pedro Valley there are but two points where reservoirs can be built to an advantage:

First. On the lower portion of the valley, at a point where the foot-hills come close together, with solid rock upon each side and bottom. This is known as the Nigger Ben place, and is about 15 miles below or north of the town of Benson, where a dam 350 feet in length and 40 feet high will overflow an area of a mile square and average 10 feet deep, or a storage capacity of 278,784,000 cubic feet. The area of bottom-land and low table-land that could be irrigated by the construction of this dam would be in Cochise County over 3,000.

The second reservoir site on the valley, 1½ miles above Charleston, and 26 miles above Benson, where the foot-hills come down to the river forming solid rock banks for over a hundred feet high, where a dam 60 feet in height and 400 feet long would store over 300,000,000 cubic feet of water.

There are several places along this valley where there are broad stretches of almost level bottom-lands where under-ground dams (that is, trenches at right angles to the valley cut to bed-rock or clay and filled with concrete) could be placed, that would raise the under-ground current to such a point that thousands of acres could be brought under cultivation without irrigation and save the expense of ditches and the great loss by evaporation.

A cursory glance at the eroded condition of the banks of the San Pedro will convince a person at once that vast bodies of water run down this cañon. Great dykes of hard rock have literally been cut through by the water, large cotton-wood trees have been uprooted and carried down the stream, railroad ties, bridge timbers, iron bolts, and even steel rails are to be found miles away from where they were originally placed. So great was the damage done to the track of the Southern Pacific Railroad yearly that the company had, for the sake of economy, at great expense, to elevate its road beyond the reach of the waters from this wash. At a point where the cañon is over 200 feet wide water marks from a recent freshet still remain which are 20 feet above the lowest point of the channel. These are conclusive proofs of the fact that enormous quantities of waters flow to waste annually, whereas if it could be properly stored in a system of reservoirs it would be sufficient to irrigate thousands of acres of land which are now worthless, and which would forever remain so unless reclaimed by the waters from this cañon, because the topography of the country would not permit its being brought from any other stream or wash.

Dams.—No. 1.—At this point a large dyke of hard volcanic rock crops out on the left bank, continues on the surface until it reaches the bed of the creek, then sinks beneath the sandy bottom, to appear again on the right bank of the main channel. At the extreme right end of the dam is also to be found solid rock, so that this dam, if constructed, would have three natural and solid abutments upon which to rest, namely, one on each end and one in the middle. Besides, the indications are such that bed-rock can not be far distant from the surface of the sand. Therefore at this point a very strong dam could easily be built and, as we shall see afterwards, at a comparatively moderate cost.

The total length of this dam is 1,052 feet, and its greatest height is 67.5 feet. Its heights at different points are as follows: Commencing from the left, the first 200 feet in length would average 20 feet, the following 50 feet would be about 45 feet high, the next 200 feet, being the main channel of the wash, would reach a height of 67 feet, while the remaining 600 feet would average no more than 35 feet.

In addition to the main dam, a small one would have to be built. Its length is 150 feet, and its average height through that distance would be about 6 feet.

Above the site of Dam No. 1, along the Cienega Cañon and for a short distance up Davidson's Cañon, the waters have worn through the sediment which they had previously deposited, which averages 150 feet in width and 15 feet in depth. The fall of

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the Cienega Cañon in this locality is about 40 feet per mile; that of Davidson's Cañon about 50 feet per mile. The dam, then, being only about 34 feet above the broad basin of the canons, would back the water along the Cienega Cañon for about 4,400 feet, and up the Davidson Cañon for about 3,700 feet. The basin of the former cañon averages about 2,000 feet in width; that of the latter about 800 feet. Hence, to speak generally, this dam would create two rectangular sheets of water, one 4,400 by 2,000, and the other 3,700 by 800, or, more accurately, as found by survey, the water would cover in the Cienega an area of 9,160,073 square feet, or 210.3 acres to an average depth of 26.47 feet, taking into account the deep channel already spoken of. In the Davidson Cañon a lake would be formed containing an area of 2,784,340 square feet—63.92 acres—having an average depth of 20.50 feet.

Therefore the capacity of this reservoir would be equal to 299,580,795 cubic feet, or 2,241,019,947 gallons; in other words, it would take a ditch with an average width of 8 feet and an average depth of 2 feet, running at the average velocity of 35.6 feet per minute, 365 days to empty the contents of this reservoir, it having been once filled and no more water coming into it during the time that it is being emptied. Again, this amount of water, if spread out over a level plain, would cover 82,529 acres, or 515 one quarter sections, 1 inch deep. It has been mentioned that the waters have deposited sediment in the basins of both the Cienega and Davidson's Cañon; in fact, the soil in these basins is nothing more than this sedimentary deposit.

Dam No. 2.—This dam, too, would have solid abutments upon which to rest, and although bed-rock is not seen upon the surface in the bed of the stream it is evident that it is only covered by the sand. The span, besides, being so short, this dam could be made not only the strongest, but the least expensive. It will be seen from the diagrams that its total length is 418 feet and its greatest height is 43.43 feet, and as the banks on both sides are so steep, the dam will average a height of 40 feet through its entire length. The fall of the wash at this point is something more than 40 feet per mile; hence, the dam would back the water up stream not quite 1 mile. The basin also is comparatively narrow and therefore would not make a very large reservoir. According to surveys the water would cover an area of 2,923,658 square feet, or 67.12 acres, to an average depth of 22.37 feet. Therefore its capacity would be 65,391,298 cubic feet, or only about one-fourth as much water as that caught by Dam No. 1. This is a small quantity of water, but it will be seen hereafter how this dam is an indispensable accompaniment to the success of the large dam, No. 3.

Dam No. 3.—The banks of the Pantano Wash after leaving the point for Dam No. 2 are of a gravelly nature, more or less strongly cemented together. At places where the current of the main channel cuts into the sides a hard conglomerate, somewhat of the nature of "caliche," is exposed. At no point, however, do we find croppings of solid rock. Dam No. 3 would not have the natural rock supports of dams Nos. 1 and 2. It is doubtful, too, whether bed-rock would be reached in the construction of this dam; hence we can anticipate a loss by seepage underground. However, if a puddle wall of clay or some other good material were built through the sand until it reaches the conglomerate to which reference has been made, and which is quite impermeable to water, this loss could be, if not altogether stopped, at least very greatly diminished. The red sandy clay from which the Indians make their "ollas" and which abounds in the mesas in the vicinity, would be a most excellent material with which to build such a puddle wall.

The total length of this dam is 2,640 feet, or exactly one-half mile, and its greatest height is 73.96 feet. For 600 feet it would have an average height of about 50 feet, and for the remaining distance its height would average nearly 70 feet. It would back the water up the cañon a distance of 7,500 feet, the average width of the basin being about 3,000 feet. As found by our surveys, this reservoir would extend over an area of 22,400,017 square feet, or 514.23 acres, having an average depth of 33.53 feet; that is, it would contain 752,169,384.8 cubic feet of water. It will be noted that this amount is over twice as much as that which the other two reservoirs would hold. It would take one year to discharge this amount of water through a ditch 12 feet wide by 4 feet deep and running at a velocity of 29.42 feet per minute; or if this quantity of water were spread 6 inches deep over a level plain it would cover 34,484.26 acres, or 53.88 square miles; that is to say, it would flood a strip of level land 25 miles long by 2⅛ miles wide, 6 inches deep.

IN YUMA COUNTY, ARIZONA.

The most available site for a dam 100 feet in height is at a point on the river about half a mile above the South Gila Canal Company's head-gate. Solid bluffs of dolomite (limestone) 111 to 125 feet above the present water-level and distant 1,595 feet from each other are found at this point. The width of 1,595 feet given is the distance between the bluffs at the 100-foot flow line, or proposed top of dam. The storage capacity of the cañon extending about 1½ miles up the river from the dam to Oatman

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Flat is comparatively small, for the average width on the 100-foot flow-line is but one-half a mile, with steep bluffs on either side.

Above this one-half mile point the bottoms widen out to an average width of 1½ miles for 3 miles, forming what is called Oatman Flat, with an area of 4.7 square miles on the 100-foot contour. At the head of Oatman Flat the bottoms narrow to about three-quarters of a mile, and then widen out and form Cottonwood Flat, the main storage basin, with a length of 8 miles and a width of 4½ miles, with an area of 35.2 square miles. About 2 miles above the head of Cottonwood Flat, at Rock Islands, the bottom narrows to a width of about 2,000 feet, including an island 500 feet wide, and above this point they again widen to 3 miles. The length of this basin will be 8½ miles, with an area of 8½ square miles.

The depth of the water at the lower Rock Island will be 40 feet. The average fall in the river from this point to the dam, some 14 miles by the river channel, is 4.3 feet per mile. The river has a much greater grade above the Rock Islands.

The distance from the islands to Gila Bend is about 20 miles. The total area of the three basins is as follows:

	Square miles.
Oatman Flat	4.7
Cottonwood Flat	35.2
Gila Bend Flat	8.5
Total flowage (with 100-foot dam)	48.4

As there will be considerable evaporation from a body of water in this hot summer climate, estimated at half an inch a day for six months, equal to 7½ feet, I assume the average available depth to be 35 feet, which with an area of 48.4 square miles will store 47,227,009,600 cubic feet. This will give a daily supply for six months of 262,372,200 cubic feet, equal to 151,835 miners' inches of the California standard.

The proposed storage reservoir is situated on the Gila River about 100 miles northeast of the town of Yuma and a few miles east of the boundary line of the county. At this point the river is subject to heavy floods that will insure the filling of the reservoir every winter and spring, the heavy flow lasting until the 1st of May.

About the 1st of June the works would be called upon to make good the diminishing supply in the Gila. This draft would be at its maximum in July and August. The evaporation in this climate is very great, but the engineer has allowed amply for the losses thereby incurred. The depth of evaporation in inches averaged for every month in the year, as shown by the Signal Service records at Yuma, is as follows:

	Inches.		Inches.
January	4.4	August	10.2
February	5.2	September	8.2
March	6.6	October	8.2
April	9.6	November	5.5
May	9.6	December	4.6
June	12.6		
July	11.0	Total	95.7

The rain-fall is practically insignificant. The monthly fall in inches, averaged for eleven years, is given herewith:

	Inches.		Inches.
January	0.403	August	0.496
February	0.532	September	0.060
March	0.217	October	0.124
April	0.120	November	0.180
May	0.062	December	0.403
June	Inappreciable		
July	0.155	Total	2.752

The drainage basin supplying the river is known to be enormous and its service constant during certain months. At the lowest rate of calculation in use in California—1 inch to 4 acres—the amount of water stored would suffice to irrigate over 600,000 acres. Rock suitable for the construction of a masonry dam is found in unlimited quantities adjacent to the proposed site. Elsewhere we have endeavored to show that large and constant water supplies are imperatively needed. While it is true that the several canals along the Gila cover considerable areas, it is also true that the Oatman Cañon reservoir will bring very much larger tracts under control, and, therefore, an increased population, much larger property valuation, vastly augmented agricultural output, and consequently greater prosperity. With storage works of the described capacity a permanent summer supply of water could be relied upon to thoroughly irrigate most of the accessible arable land in southern Yuma County lying below the reservoir, and thus remove the present cause of non-development of this fertile section. It has been explained that about 25 per cent. of the valley land is overflowed

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by the river during certain regular periods. The establisnment of such works would also reclaim the bottoms by storing the surplus water that would otherwise, at such seasons, flood the surface, and do great injury.

CONCLUSION.—With this report a topographical map, drawn by Mr. Lewis A. Hicks, C. E., is submitted, showing the entire lower Gila Valley from Oatman Cañon westward to the Colorado River, and also all the lands between the Gila River and the Sonora frontier. Two lines are drawn, the first indicating the extent of the area that would be capable of producing at least one crop of cereals or forage each year, supposing the dam to contain 25 feet of water. This second line shows the limit of the fruit belt, but the area between these two lines will be valuable for the raising of all forage plants, sugar-beets, etc. Below their junction all the land shown will be available. The varied topographical features are faithfully and intelligently delineated and will greatly assist in a correct understanding of the subject treated in these pages.

The vast importance of the inquiries set in motion by the Senatorial committee, and their direct bearing upon our own surroundings, are fully understood by the people of Yuma County, who highly appreciate the opportunity of placing before their distinguished visitors such data concerning the quantity and quality of the lands, the necessity and future possibilities of irrigation, the number and extent of canals, the rivers and water supply, the climate and its influence upon the early maturity of crops, the products, the transportation facilities, and finally, the need of water-storage reservoirs and selection of appropriate sites as, it is hoped, may meet their purposes. If this has been accomplished, the citizens' executive committee will consider their duty as satisfactorily performed.

That the western portion of valley or bottom lands of the Colorado River, properly irrigated, can be made one of the finest farming sections of the United States is no longer a question among those who have investigated the subject.

In the Annual Report of Indian Affairs in Arizona, 1867, I find the following:

The experiences of this season have proved beyond doubt, were evidence on the subject still wanting, the thorough capability of the lands of the Colorado River Valley for all the purposes of agriculture in every case where water can be made to reach the surface. To depend upon the annual overflow is somewhat hazardous, for lands reached by it one year may not be again for several, or they may be so deeply submerged as to be unavailable for planting during the season. There are thousands of acres in the reservation which the overflow from the river never reaches, but which the artificial application of water would render as productive as any of the lands that are naturally overflowed.

All experience from that time up to the present proves the correctness of the ideas of that paragraph.

THE SWEETWATER DAM, SAN DIEGO COUNTY, CAL.*

BY JAMES D. SCHUYLER, M. AM. SOC. C. E.

The question of an adequate water supply for irrigation as well as for the domestic use of cities and towns is one which in San Diego County, Cal., necessarily involves storage reservoirs. The streams of the county are of an intermittent character. The mountain ranges in which they head and from which they flow to the coast do not generally exceed 6,000 to 6,500 feet in elevation—an altitude too low in the latitude of San Diego to maintain perpetual snow upon their summits, or even to retain such proportion of the water precipitation as comes in the form of snow (not usually more than 10 per cent.) for more than a few days or weeks. As a result the streams are torrential in winter and carry large volumes of water, but in summer and fall, when most needed for irrigation, are almost dry for 20 to 30 miles of their lower course, with the exception of certain seasons of such unusual rain-fall that no irrigation is required—seasons that come at rare intervals. Ordinarily the streams in summer reverse the usual order of nature, and are largest at the small end, and to get a water supply the engineer must either go far back into the mountains and gather together a number of small living streams and springs and pipe them out long distances, or construct dam and storage reservoirs to retain the winter floods. Fortunately nature has

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compensated for the existing conditions by providing numerous favorable sites for such construction, and every stream of importance in the county has available sites for storage dams of large capacity. A number of water companies are engaged in preparing for extensive works of this character, which, when completed, will provide irrigation facilities for several hundred thousand acres of land otherwise unproductive.

This era of development was inaugurated but recently, and the first completed work of the character is the Sweetwater Dam and Reservoir and extensive pipe system reaching out from it.

The circumstances which led to the building of the dam were that the San Diego Land and Town Company (a first cousin of the Atchison, Topeka and Santa Fé Railway) owned a large body of fertile and desirable mesa and valley lands bordering on San Diego Bay, adjacent to San Diego on the south, which were unsalable without water to irrigate them. These lands constitute the greater part of the "Rancho de la Nacion," including the town site of National City, which also languished with thirst. The Sweetwater River passes nearly through the center of the lands, and is of the nature described—intermittent in flow, at least for many miles above its mouth.

The first storm or two of the rainy season is absorbed by the thirsty earth, and the stream generally does not begin flowing into the bay until late in December or in January. After each heavy storm thereafter its volume will reach 500 to 1,000 cubic feet per second for a few days, and within a fortnight recede to 10 cubic feet per second.

The last severe storms of the rainy season are usually in March, and the flow of the stream will generally dwindle to 1 or 2 cubic feet per second by June 1, which amount may be maintained through the remainder of the year, but not always. The large supply running to waste each year, followed by months of scarcity, naturally suggested storage, and the first cañon above the mouth of the stream was selected as the place to accomplish the object. This narrow gorge, 7 miles east of the bay, is a deep and narrow cut, half a mile in length, through a dike of trap rock or trachyte that intersected the valley of the Sweetwater, leaving above it a broad level valley some 3 miles long, one-quarter to three-quarters of a mile in width. This is the site of the reservoir formed by the dam built at the head of the gorge.

The construction of this dam was decided upon and work begun in November, 1886. The original plan designed was a narrow wall of concrete masonry, 50 feet high, 10 feet wide at bottom, 3 feet on top, arched up-stream. On the upper side an embankment of loose earth was to be filled in against the masonry wall to its full height. After two months' work had developed the character of the design, the plan was disapproved by the management, and the writer was called upon to design a suitable structure and execute its construction. Some $35,000 had already been expended, and in order to utilize as much of the old work as possible the new structure was planned to rest upon and incase the foundations already laid. This decision influenced to some extent the radius of the arch of the new dam, as well as its position relative to the axis of the cañon, and the location of the anchorage on the sides. In other words, to avoid throwing away the work already done, the new work was adapted to the old in a way that ultimately increased the length of the dam on the crest somewhat more than would have been necessary by shifting the point of radius to one side of the central axis of the cañon, and making the radius somewhat shorter than it otherwise would have been. An engineer is sometimes driven to adaptations of this sort against his judgment, to save, or to give the appearance of saving, the pockets of his employers.

The modifications of the original plan were radical ones. The combination of earth and masonry was rejected, as it seemed to the writer that water alone was sufficiently heavy for the masonry wall to support without adding the last straw on the camel's back, of a mass of saturated earth. A gravity profile was adopted, and rubble masonry formed of blocks of stone up to 4 tons weight was substituted for bastard concrete composed of cement mortar, with small stones rammed into it, which had been previously used. So much of the old plan was retained, however, as to form an embankment 50 feet wide on top, 10 to 15 feet high across the cañon, against the face of the wall, but clay well rammed in layers was substituted for the silt and quicksand loosely dumped, with which the dam was formerly being made. The object of this clay filling was to cut off possible seams in the bed rock underneath the dam and reduce the pressure on the structure. The top of the embankment is 70 feet below the top of the dam.

The foundation.—After the bowlders, sand, and gravel had been stripped from the base of the dam on either side of the old work, the bed-rock was found to be very irregular in surface, presenting the appearance of a number of pyramids and cones thrown heterogeneously together, but bound solidly in one mass and well polished by attrition. The rock was very close in texture and exceedingly hard. No attempt was made to cut out the bed in the level benches, as the unevenness of the bottom, as

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nature left it, gave the assurance that whatever movement might occur in the structure built on such a base there could be no possibility of its slipping or sliding on the base. Wherever there were seams in the rock they were invariably occupied by roots, and the excavation was carried down till the seams pinched out and the roots disappeared. The rock was then thoroughly scrubbed by hand, and a thin grout of pure cement applied with brooms, filling the minutest crevices and angles in the rock, before starting the masonry.

The side walls of the cañon required more excavation to reach a satisfactory anchorage than the bottom. The north side was composed of shattered rock scored with innumerable seams filled with red clay. In this material the excavation was carried to a depth (perpendicular to the slope) of 20 to 25 feet before a solid ledge free from seams was encountered. This ledge lay with a slope nearly parallel with the surface slope, and in direction so nearly parallel to the radial line of the curve of the dam that it could not have been better placed to receive the arch thrust and formed a natural skew-back. This was carefully stripped and treated with cement grout in the same manner as the base.

The abutment on the south side was against the end of a dike of trap-rock, crossing over the hills to the south in a direction nearly parallel to a line passing through the center of radius and dipping westward at an angle of about 10 degrees from the vertical. After cutting into the face of this rock 5 to 10 feet all seamy, loose material was stripped away, and a bedding that was deemed sufficiently good was obtained, although the rock was not as free from seams nor as solid in mass as the north abutment. However, the entire foundation is an admirable one, of rock in place throughout.

The plan.—The original height of 50 feet was arbitrarily adopted at the beginning of the work, without any special investigation of the quantity of water to be stored by a dam of that height, but was "guessed" to be sufficient for present necessities, and the estimate of its cost was considered to be about the limit of the expenditure the company cared to make on an experimental scheme. There was an immediate and pressing need for water, the rainy season was passing, and it was desired to get up a part of the structure as rapidly as possible in order to catch a partial supply for the coming summer. Accordingly, in compliance with this desire, the foundation was rapidly laid and the structure hurriedly carried up to a point where it was safe to begin catchment. The base of the dam was laid with a width of 36 feet, and at a height of about 15 feet above the lowest course it was drawn in to a thickness of 24 feet. At this level (whose elevation above tide is 140 feet) the lowest pipes pass through the dam. Above this level the structure was carried to a height of 45 feet, with a top width of 5 feet, base as stated of 24 feet, face batter (up-stream) of 1 to 6. In anticipation of a probable addition to the height of the dam in future, the back was built in three steps, to give an opportunity of bonding the new work to the old. The profile of this portion of the structure is shown in Plate XXX. It was a gravity profile, whose line of pressure passed within the inner third of the base. It was constructed in arch form, convex to the stream, on a radius of 225 feet on the face line at top.

During construction the stream was carried in a conduit 30 inches square through the masonry near the bottom of the original creek bed. But one storm of the season of 1886–'87 (a dry one) swelled the creek sufficiently to exceed the capacity of this conduit, and then it rose and ran over the top of the masonry for two days only, without injury. This occurred February 14 and 15, 1887, when the flow reached a maximum of about 500 cubic feet per second. The gate at the upper end of the conduit was finally closed April 20, 1887, and the conduit was filled solid with masonry from below. From that time until June 1, the catchment was about 80,000,000 gallons.

By the 1st of June the structure, as planned, was completed to the height of 60 feet above the bottom, 10 feet higher than the height originally contemplated. It contained about 7,500 cubic yards of masonry and had cost, all told (including the preliminary experiments), about $100,000. Meantime, surveys of the reservoir basin and water-shed had developed the fact that the 60-foot dam would impound 1,221,000,000 gallons, whereas its extension to 90 feet in height would give a capacity of nearly five times that quantity, or 5,882,000,000 gallons. Also that the area of the water-shed tributary to the dam is about 186 square miles, of which one-third is above an elevation of 3,000 feet, and between that elevation and 6,500 feet. The water-shed was evidently ample to justify the hope that the greater reservoir would be filled almost every year of ordinary rain-fall. The increased volume of water stored would so largely extend the utility of the works, and give so considerable increase in security against the disasters following a severe drought, that the increased expense of extending the height of the dam while the working force and plant were on the ground and fully organized, seemed to be immediately justifiable. These arguments were embodied in a report, which was favorably considered by the directors of the company, and orders were given, about a fortnight before the 60-foot dam was completed, to extend the structure to a height of 90 feet.

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This somewhat extended account of the growth of the enterprise from small beginnings is necessary to an understanding of the causes that led to the building of the structure in two sections rather than as a mass. The fact is that the work was nearly half done before all the conditions were thoroughly understood—conditions which ordinarily in works of such magnitude and importance are known, studied, and exhaustively discussed preliminary to the beginning of any work whatever.

In designing the plan of the higher structure, greater reliance was placed upon the arched form than in the lower dam, then approaching completion. The profile adopted was one which theoretically gave stability by its own gravity, but without as large a factor of safety. The line of pressure falls about the center of the lower third. It was reasoned that, as the foundation was as near perfection as can be generally found, apprehension on that score was unnecessary—and the source of the failure of such of the great masonry dams of the world as have given way—insecure foundation—need not be regarded as a factor in this case. If one can imagine a monolith to be carved in the form of a true arch, of such weight and dimension that any section of it is capable of withstanding the pressure of quiet water against it to its full height, without sliding or overturning, and such a monolith be firmly wedged between the rock-bound walls of a narrow cañon, the possibility of its being ruptured, displaced, or destroyed from water pressure alone can not readily be conceived. Now, if by the use of rich cement mortar and the best of building stone a structure be formed of the same dimensions and in the same position, which in time becomes virtually a monolith, based on the firmest of bed-rock, its stability must be equally assuring to the mind.

The dimensions adopted were the following: Base, 46 feet; top thickness, 12 feet; height, 90 feet; radius of arch, 222 feet on line of face at top. The face batter of 1 to 6 was carried to within 6 feet of the top; thence to the top of the parapet wall, vertical. The batter on the back started at the top with 1 to 3 for 28 feet; thence 1 to 4 for 32 feet; thence 1 to 6 to the coping.

The construction.—When the new work was begun at the base of the completed structure, special care was taken to secure a perfect footing for the toe. When the foundation was stripped it was found that there was a slight leakage at various points along the bottom of the masonry, amounting altogether to about 10,000 gallons daily. The only perceptible leakage through the masonry was along the sides of the waste conduit, which had been recently filled in, although there were moist spots all along near the bottom.

All the leakage was entirely cut off by the new work, although it was necessary to carry up small well-holes alongside the old masonry to within about 15 feet of the level of the water surface in the reservoir, and keep them pumped out, before it was safe to close them entirely. Water was standing in the reservoir at a height of about 35 feet above the base of the dam, and the small quantity of leakage, and the ease with which it was stopped, was considered a favorable test of the superior quality of the masonry.

The stone used was of two grades, a dark blue and a gray metamorphic rock, impregnated with iron. The gray stone is full of minute quartz crystals, and is of slightly less specific gravity than the blue stone, which carries more iron. It was obtained from a quarry opened in the face of a vertical cliff over 100 feet high, situated 800 feet below the dam. It has no well-defined cleavage, and broke out in irregular masses, although generally having one or more tolerably smooth faces. Numerous tests of its specific gravity gave its weight as 175 to 200 pounds per cubic foot. The average weight of the masonry in place was estimated at 164 pounds per cubic foot, which was the value used in the calculation of stability and strains.

Portland cement of the best obtainable quality was used in the proportion of one part of cement to three parts of sharp river sand. For the upper 4 feet next to the water a richer mixture of one to two was used. The sand was clean, sharp, and of the most suitable degree of coarseness to make the best of mortar.

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The cost of the flowage tract for the reservoir is not included in the above. A little over one-half the land cost $16,426.93. The remainder is in litigation under an action of condemnation. A San Diego jury, under the stimulus of "boom" prices, awarded the owner $280 an acre, or a little over $100,000 for land, one-third of which was worthless, and the remainder unimproved. This judgment is being contested before the Supreme Court. The clearing and grubbing of about 300 acres of the reservoir basin cost $10,808.46.

The wasteway.—This important adjunct to the dam was carefully considered and proportioned to carry the probable maximum flow of the stream that may be presented for discharge, with a full reservoir. It is located at the south end of the structure, and is 40 feet in length by 5 feet in depth, divided into eight bays of 5 feet each. These bays are formed by piers of masonry, set at right angles to the flow, and provided with recesses on the upper face, in which loose flash-boards of 2-inch plank rest on an incline of 35 degrees from the vertical. Any set of boards may be removed

from top to bottom, or the water may be held at successive levels from the top to the bottom of the weir by removing the top boards all the way across. The water falling over the wier drops into a series of pools, 3 feet deep, which relieve the structure of shock, and passes down an inclined plane with a fall of 1 to 10, until it is carried away from the dam a distance of 50 feet, and then plunges into the cañon below. The capacity of the wasteway is about 1,500 cubic feet per second. This may be increased to about 1,800 cubic feet per second by opening a 30-inch blow-off gate in the main pipe below the dam.

The inlet tower.—This structure is located 50 feet above the dam, nearly opposite its center. It is built of masonry, with cement morter mixed two to one, plastered outside and in with two coats of mortar mixed with one of sand to one of cement. It is 16 feet square at the base for a height of 10 feet, where its form is changed to a hexagon, with walls of a uniform thickness of 3 feet to the top. Each of the sides of the hexagon measure 3 feet on the interior face. Into the walls of the tower are built seven cast-iron elbows, at an elevation of 10 feet apart from bottom to top, the upper one being 10 feet below high-water line. The bell-mouths of the elbows open upward, and are ordinarily closed with a plain valve or cover of iron. The design is to draw water from the surface at whatever stage it may be. When any one cover is removed, a basket screen is lowered in its place, fitting closely into the mouth of the elbow. Three pipes pass through the dam and enter the tower at the bottom. The two lowest pipes are of cast-iron, 14 and 18 inches in diameter respectively, and lie side by side. They are encased in concrete throughout, from the tower to the dam. On top of them is built a conduit of masonry with a circular orifice 40 inches in diameter, formed of walls 30 inches in diameter, in double arches. This conduit leads from the interior of the tower to the center of the dam, where it joins a pipe of ¼-inch boiler-iron, 36 inches in diameter, leading to the main gate immediately below the dam, and from this gate is carried the main pipe line down the valley. The smaller pipes are not at present used, except to supply a hydraulic ram throwing water to the keeper's house on the hill, 150 feet above, and to drain the tower when all the valves are shut. They are intended to be used for supplying a turbine and pump to throw water to a higher level than the dam will now reach.

As an illustration of the fact that masonry laid in Portland cement in the proportion of two of sand to one of cement may be made water-tight with care exercised in laying, this tower, and the conduit leading from it, may be cited. When they are empty the pressure from the outside at present is somewhat more than 20 pounds per square inch on the conduit and at the bottom of the tower, and there is no leakage in either of them.

The reservoir.—Red clay soil constitutes the bed of the reservoir basin, or the major portion, outside of the old river-bed and bottoms, and is of an impervious nature. The following table of area and contents of reservoir is presented:

Contour elevation.	Area.	Contents.	Contour elevation.	Area.	Contents.
Feet.	*Acres.*	*Gallons.*	*Feet.*	*Acres.*	*Gallons.*
145 (level of lowest outlet valve in tower)	3.51		180	200.77	835,851,000
150	10.72	11,640,000	185	272.22	1,221,355,000
155	17.12	30,577,000	190	326.96	1,710,583,000
160	43.10	79,631,000	195	397.85	2,302,261,000
165	75.21	175,819,000	200	463.80	3,005,642,000
170	113.40	329,546,000	205	538.94	3,824,197,000
175	153.75	547,069,000	210	630.94	4,778,549,000
			215	721.86	5,882,278,000

The table shows that 80 per cent. of the capacity of the reservoir is within the upper 30 feet of height, and that 40 per cent. is within the last 10 feet. This fact reduces within small limits the fluctuation of head on the mains after the reservoir is once filled, and constitutes one of the reasons for increasing the height of the structure, as it enables the establishment of the probable limit of irrigation on the lands below, at a line not lower than 25 to 35 feet from the top of the dam. The irrigable area was thus largely increased, by reason of the decrease in fluctuation of depth in the reservoir.

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The distributing system.—From the dam to the lower end of the cañon, 1,600 feet, the main pipe is 36 inches in diameter, and covered with masonry laid in lime mortar, plastered with cement. From this point it is reduced to 30 inches diameter, and follows the valley for 5 miles, and thence rises to the top of the Chula Vista mesa, 92 feet above sea-level. Its entire length is 29,800 feet, and at its terminus the water is divided into two 24-inch pipes, one running south 1 mile, the other west half a mile, where it is reduced to 18 inches diameter, and is carried northward to and through National City.

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At the terminus of the 36-inch main a blow-off gate is located, to be used as a relief to the wasteway of the dam in case of a sudden flood which might exceed the capacity of the wasteway, or to draw off the water from the reservoir if, for any cause, it was desired to do so.

Wrought-iron pipes were used throughout. The total length of mains and laterals that have been laid is 58 miles, with 5½ miles on hand to be laid this season. They are of three classes, viz, straight double riveted pipe; converse lock joint, kalamined lap-welded tube; and spiral riveted pipe. About 16 per cent. of the pipe was of the first-class, 72 per cent. of the second, and 12 per cent. of the third.

The introduction of spiral pipe into the system was unfortunate, as it does not stand the test of transportation across the continent, and will have to be taken up and specially treated to make it water tight. It will answer very well for subirrigation, if it could be properly controlled, but as it is laid in streets and avenues that system is not desirable or conducive to comfort in traveling.

The total cost of the pipe lines was as follows:

Pipe	$301,928.80
Freight	39,183.03
Distribution	6,271.06
Gates	1,849.62
Materials, tools, etc	5,932.57
Right of way and miscellaneous expenses	2,968.00
Pipe laying	144,630.78
Total	502,763.86

Probable duty of the works.—One of the most interesting questions to the stockholders of the company is the result that may be reasonably expected in the way of irrigation from such a reservoir. The assumption is made that in average years, say three out of five, the water-shed will yield a sufficient supply to fill the reservoir, besides maintaining the consumption through the rainy season, thus starting on the irrigation season about May 1 with a full reservoir. From May 1 to October 1 is the average season of irrigation—about 150 days. Where pipe distribution is in use, a fair average allowance in southern California is a duty of 10 acres per miner's inch (500 acres per cubic foot per second). There are instances of a much higher duty having been attained—a duty of even 40 acres per miner's inch having been accomplished in one place. Alloting 700,000,000 gallons for the annual consumption of National City, and for loss by evaporation during the summer months, the remainder would yield a flow of 2,000 miner's inches per day for 200 days; with a duty of 10 acres per inch, this amount would irrigate 20,000 acres. In the course of time it is expected that a duty as high as 20 acres per inch will be reached, in which event a reservoir full may be extended over two years' time, and still irrigate 20,000 acres, and afford a domestic supply to the town of National City.

Water rights, giving to the purchaser simply the privilege of becoming a customer for water, have been sold on the San Diego Flume Company flume at the rate of $2,000 per miner's inch. At this rate the value of the irrigation supply of the reservoir is $4,000,000. The construction of the works has already added a value of $1,500,000 to the principal tract of 5,000 acres which has been supplied with a complete system of water-pipes, and another million to the value of town property in National City, and lands in its immediate vicinity.

A BOLD PROJECT.

It is proposed to permanently lower Tulare Lake to 15 feet below the present level, which will reclaim 375,000 acres, including swamp land, all now under water or subject to frequent overflow. This is to be effected by a canal of 12 feet average depth, which is to extend from Tulare Lake to a junction with the San Joaquin River at the head of navigation, distance about 40 miles north from the lake. The line of the canal will be through the present swamp which extends north from the lake. The level of the river at the junction is 48 feet below the level of the lake, and thus affords a sufficient fall for the discharge of the surplus water of the lake proposed to be drained. An additional outlet is also afforded by a projected west side irrigation scheme, which is to take water from the canal for the irrigation of over 400,000 acres of valley lands, the proposed canal forming, with Tulare Lake, a continuous inland water-way of over 70 miles. It is expected by its affluent discharge of water into the Upper San Joaquin River to so improve navigation as to utilize it for heavy freight.

VALUE OF THE PIPE SYSTEM.

Civil Engineer F. Eaton, of Los Angeles, makes the following statement relative to pipe service:

The duty of our streams would be extended by extending the present ditches by pipe systems. Experience has taught us that by economizing the water it is not only the water that we save in seepage alone, but the distribution. The convenience that these pipe systems offer in the distribution of water is a great economizer. We find that we can get along with a half or third the water that we get in running it around in ditches. It was thought that the San Gabriel was being used up by irrigating 2,000 acres; but it has been used since for irrigating 12,000 acres; and it can be increased by the pipe system. The duty of one-fiftieth of a cubic foot per second throughout the valley under the pipe system would be 1 inch to 10 acres; that is, for vegetables and all kinds of crops. It depends altogether on the character of the soil. A soil that is well subdrained, that is composed of gravel, will require much less water. Such subsoil is a natural drain, and for that reason water will go a great deal farther on that kind of land than it will on an impervious subsoil. Taking the average in the San Gabriel Valley, with 10 inches you can irrigate all kinds of crops, orange trees, and all kinds of vegetables. The cost runs from $15 to $50 per acre. The cement pipes are not cheaper than the pressure pipes, because it requires a good many more of them, and they are not so convenient as the pressure pipes. We generally use 16 iron. It is practically the sixteenth of an inch thick. A 4-inch pipe is more difficult to make than a 16-inch. We put asphaltum on, but it is impossible to keep it from being knocked off in spots, and those spots rust there. We can not inspect them closely enough to get at them all and paint them over. In ordinary soil, where there is no alkali, it will wear fifteen or sixteen years. I put in pipes fifteen years ago that are doing service now. The Pasadena pipes were 11 inches with 18 iron. That system was put in in 1873, and served up to this year. We have not many storage facilities up in the mountains. They are confined practically to the foot-hills and the valleys. We have to bring our water down and make our reservoirs in the valley. In Bear Valley the reservoir will contain 60,000,000,000 cubic feet when it is fully developed, and I am told there are a number of similar ones up there; but the cañons are too precipitious.

KERN COUNTY, CALIFORNIA, AND ITS IRRIGATION WORKS.

The average discharge of Kern River is 2,700 cubic feet per second. The maximum discharge during the rainy season and during the melting of the mountain snow is 19,041 cubic feet per second. There are eight months of the maximum flow or high water, from December to July, inclusive. The actual discharge of Kern River the last of May, 1883, by calculations made, was found to be equal to a depth of 1½ inches per month from the whole area or catchment of 3,445 square miles. This gives a depth of 3 inches per month for irrigation over 1,200 square miles, or 768,000 acres. The discharge is doubtless much larger from the middle of February to April, when water is most needed for irrigation. By close calculation it is found that 1 cubic foot per second will irrigate 160 acres.

In this valley, and mainly on Kern Island, are more than thirty canals, some of them with branches and all with distributing ditches, and several with many, the main canals aggregating some 300 miles in length and covering nearly 475,000 acres, which can be irrigated. About 150,000 acres are now irrigated. On these irrigated lands, with good care, alfalfa gives four and five crops a year, yielding at least 2 tons to the acre each crop, making an annual yield of 8 to 10 tons to the acre besides affording some pasture. As a rule it is cut every six weeks for eight months in the year. Several years ago, when this irrigating system was first inaugurated, it cost 50 cents per acre to irrigate land. Science and art, with much study and labor, have so far perfected this system of irrigation that now the cost varies from 2 to 10 cents per acre, as a rule averaging from 2 cents or 3 cents to 5 cents under favorable conditions.

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The canal of the Kern River Water and Irrigating Company, known as the Beardsley Canal, the highest on the river, being the most northeasterly of this great system, is taken from the northerly bank in the southeast quarter of section 3, T. 29 S., R. 28 E. It is 8 miles in length 15 feet wide on the bottom, and 2½ feet deep. It has 10 miles of distributing ditches. It appropriates 47,030 miner's inches under a 4-inch pressure, equivalent to 938 cubic feet per second. This location was made December 2, 1873.

The McCord Canal is taken from the northerly bank of the river in the northeast quarter of section 18, T. 29 S., R. 28 E. The main canal is 4½ miles long, with three branches, having a total length of 10 miles and 15 miles of distributing ditches. The main canal is 20 feet wide on the bottom and 2 and 3 feet deep. This, with the Beardsley, is the means of supply for that portion of the district above the Calloway Canal. It appropriates 5,000 inches, equivalent to 100 cubic feet per second. This location was made March 20, 1875.

The Calloway Canal belongs to the Kern River Land and Canal Company, and is the largest and most important in the system. It comes out of the northerly bank of the river a short distance above the Southern Pacific Railroad Company's bridge, in the southeast quarter, section 13, T. 29 S., R. 27 E. It is 32 miles long, 80 feet wide on the bottom, and 120 on the surface, with banks 7 feet high and 10 to 16 feet wide on top, with inside slope of 4 to 1, and outside 2 to 1. On the west bank there is a delightful driveway the full length. It has a depth of about 6 feet. The grade is eight-tenths of a foot per mile. In 30 miles it crosses Poso Creek by means of a weir 150 feet in length, built in the bed of the creek, and connecting at either end with the lower bank of the canal. This arrangement admits of the use of the winter waters of Poso Creek by diverting them into the canal. It has some sixty-five distributing ditches, from 8 to 20 feet wide on the bottom, averaging 16 feet, and from 1 to 9 miles long, the aggregate length being about 150 miles. These branches have banks 3½ feet high, intended for 3 feet of water, with slopes 3 to 1, and a grade of $1\frac{6}{10}$ feet per mile, giving to each a capacity of $196\frac{5}{10}$ cubic feet per second. The importance of this canal is seen when we state that it covers about 200,000 acres of land. The head-gate at the point of diversion from the river is 100 feet long, built of redwood lumber, 6 by 6 struts, 4 by 6 side posts, and 2-inch flooring. The foundation is 20 feet wide up and down the stream, and has three rows of sheet piling, 4 by 8 Oregon pine, driven to a depth of from 12 to 16 feet, with intermediate or anchor piles of the same dimensions and material to which the sills, 4 by 8, redwood are spiked. There are 25 bays, and the gate-boards are 2 by 6 redwood. The top of the gate is 8 feet from the floor. The gate extends from the right bank out into the stream, and is connected with the weir by an artificial abutment. The weir extends from this abutment southerly across the river, and is 400 feet long, being of similar construction to the head-gate, the only difference being that the gate-boards are twice as long, reaching across the bays. By means of the gate-boards, which are movable, the water is under complete control, and can be regulated at will. The Calloway appropriates 74,000 inches of water, equivalent to 1,476 cubic feet per second. The location was made May 4, 1875.

The McCaffrey Ditch, sharing the head-gate of the Calloway Canal, is 3 miles long, 7 to 8 feet wide on the bottom and is 2½ feet deep. It irrigates the land between the Calloway and the river. The appropriation is 1,296 inches, equivalent to 26 cubic feet per second. The date of location is October 31, 1874.

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The head-gate of the Emery Ditch is in the northeast quarter of section 22, T. 29 S., R. 27 E. It is 3 miles long, 6 to 8 feet wide on the bottom, and 2 feet deep. It appropriates 2,000 inches, equivalent to 40 cubic feet per second. Located December 2, 1876.

The Jones and Tuckey Ditch begins in the northeast quarter of section 32, T. 29 S., R. 27 E. It is 4 miles in length, 10 feet wide on the bottom, and 2 feet deep. The appropriation is 1,000 inches, equivalent to 20 cubic feet per second. Located June 24, 1876.

The Railroad Canal, commencing near the corner of southwest quarter of section 31, T. 29 S., R. 27 E., is 3,000 feet long. It is 40 feet wide on the bottom, and 2 feet deep. It empties into Goose Lake slough. It appropriates 31,075 inches, equivalent to 620 cubic feet per second. Its location dates July 24, 1874.

The head-gate of the Wible Canal is in the northwest quarter of section 6, T. 30, S., R. 27 E., and running about 1,000 feet, it discharges into Goose Lake Canal, and by means of this canal and Goose Lake slough, its waters are conveyed to the lands to be irrigated. It is 40 feet wide on the bottom, and 2 feet deep. Its appropriation is 5,040 inches, and its capacity 300 cubic feet per second. Located May 1, 1875.

The property of the Goose Lake Canal Company is taken from the northerly bank of Kern River, in the northeast quarter of section 1, T. 30 S., R. 26 E., and runs thence northwesterly 4½ miles, emptying into Goose Lake slough. Flowing through this slough the water is taken out at different points along the slough in ditches. It is 140 feet wide on the bottom and 3 feet deep. It appropriates 90,000 inches, equivalent to 1,795 cubic feet per second. It was located July 13, 1875. The Railroad, Wible, and Goose Lake Canals all empty into the Goose Lake slough, and use it as a common channel to carry their waters to the adjoining lands as far down as Goose Lake, a distance of 22 miles.

The Pioneer Canal, owned by the Pioneer Canal Company, has its head-gate in the northeast quarter of section 1, T. 30 S., R. 26 E. It has a length westerly of 11½ miles, being 60 feet wide on the bottom and 3 feet deep. This canal flows through the entire lengh of the McClung ranch, which is wholly irrigated by it and its principal distributing branch, the Pottinger Ditch, 16 feet wide. It also passes through the Buena Vista ranch, furnishing mainly its irrigating waters. Its appropriation is 20,074 inches, equivalent to 400 cubic feet per second. This canal was located April 26, 1873.

The head-gate of the Edwards Ditch is in the northwest quarter of section 1, T. 30 S., R. 26 E. It is 2 miles long, 10 to 12 feet wide on the bottom, and 1 foot deep. It appropriates 1,440 inches, equivalent to 20 cubic feet per second, and was located December 21, 1874.

The James and Dixon Canal is owned by the James and Dixon Canal Company. It commences in the southeast quarter of section 3, T. 30 S., R. 26 E., and runs in a westerly direction about 12 miles. It is 30 feet wide on the bottom and 3 feet deep. Its appropriation is 14,000 inches, equivalent to 279 cubic feet per second. Its location dates April 19, 1873.

The Johnson Ditch is owned by the Lower New Kern River Irrigating Company, and begins in the southeast quarter of section 3, T. 30 S., R. 26 E, a few feet below the James and Dixon Canal, with which its waters join in a shallow slough, a few hundred feet below. Its course is southwesterly about 4 miles. It is 30 feet wide on the bottom and 3 feet deep. It appropriates 8,640 inches, equivalent to 172 cubic feet per second. It was located June 12, 1873.

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The Ash Ditch is near the Johnson, and is taken from the river in southeast quarter of section 3, T. 30 S., R. 26 E., and is 1 mile in length, 3 feet wide on the bottom, and 2 feet deep. It has a discharging capacity of 24 cubic feet per second.

The May Ditch leaves a short arm of the river in the northwest corner of the southwest quarter of section 18, T. 30 S., R. 26 E. It is 2 miles long, 8 feet wide on the bottom, and 2 feet deep. Its appropriation is 4,000 inches, equivalent to 80 cubic feet per second. Its location was made November 29, 1873.

The Joice Canal is taken from the river in the northeast corner of the southwest quarter of section 23, T. 30 S., R. 25 E. It is nearly 4 miles long, 12 feet wide on the bottom, and 2 feet deep. It appropriates 6,250 inches of water, equivalent to 129 cubic feet per second. Its location was made May 26, 1873.

The Dixon Canal is a branch of the Joice Canal, diverting the water from the latter for about 2½ miles, and then it branches out to the northward, irrigating lands on the borders of the reclaimed swamp-land district. It is 8 feet wide on the bottom and 4 feet deep. The appropriation is 3,456 inches, equivalent to 69 cubic feet per second. Its location dates April 13, 1875.

The foregoing canals and ditches are all on the north side of the New Kern River, or now Kern River proper. Those on the south side, about the same number, are located on both sides of Old River. The first one in order on the river, locating at the highest point on the left bank of the stream, is the property of the Kern Island Irrigating Canal Company, called the Kern Island Canal.

It is taken from Kern River near the southeast corner of the southwest quarter of section 9, T. 29 S., R. 28 E., about 2½ miles northeast of Bakersfield, through which town it passes. It is 18 miles long, with a width at the head-gate of 48½ feet on the bottom and a depth of 4 feet. It terminates at Kern Lake. At Bakersfield the canal makes a vertical fall of nearly 20 feet, furnishing water power for a large flouring mill. This important canal has two main branches, the town branch, supplying Bakersfield and vicinity, having a length of 2 miles, and a central branch, diverging from the canal south of the town, and running nearly parallel to it, varying from one-half to 2 miles distant, for a distance of 10 miles in a southerly direction. This branch has a width of 20 feet on the bottom, and a depth of 3 feet, with slopes of 3 to 1. The central branch has nineteen drops in the distance of 10 miles, placed at intervals of half a mile. The Kern Island and its branches have thirty-one lateral ditches, besides a connecting ditch with the Stine Canal, having a total length of over 80 miles. The Kern Island Canal appropriates 20,000 inches, equivalent to 400 cubic feet per second. Its location dates from the latter part of 1870.

Next below the Kern Island is the Old South Fork Canal. It is taken from the river in the central northern part of the northeast quarter of section 17, T. 29 S., R. 28 E., about three-fourths of a mile below the head-gate of the Kern Island Canal. It runs 3 miles southwesterly into the bed of the Old South Fork of Kern River, in which its waters are conveyed to Kern Lake in a nearly southerly direction. The canal has a width of 26 feet on the bottom, and is from 2 to 3 feet deep. Its distributing ditches aggregate 7 miles, one of the principal of which is the Cotton Ranch Ditch, irrigating 1,100 acres of alluvial bottom lands, north of and adjoining Bakersfield. Most of the water diverted into the Old South Fork is turned into the Panama Slough, and again diverted below by the Panama Ditch. This canal is also used at times

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as a feeder for the Kern Island Canal. The appropriation is 3,800 inches, equivalent to 75 cubic feet per second.

The Farmers' Canal, owned by the Farmers' Canal Company, takes its water from the river in the northeast quarter of section 24, T. 29 S., R. 27 E., about 200 feet above the Southern Pacific Railroad bridge across Kern River with a 48 feet opening, fronting parallel with the river, the water entering the canal at right angles with the stream. The first artificial channel to the Panama Slough is about three-quarters of a mile in length. The total length of the main channel is about 15 miles, consisting wholly of natural sloughs. It has 4 miles of branch constructions, varying from 10 to 20 feet in width. It has 30 miles of distributing ditches. The artificial channel is 50 feet wide on the bottom and 3 feet deep, and the natural channel varies from 20 to 50 feet in width, with a depth of 6 to 10 feet, having nearly vertical banks. The soil through which it passes is generally a firm, clayey loam, and permits natural irrigation of adjacent lands by percolation. A great deal of this land along the old channel is thus kept constantly moist and requires no irrigation. It appropriates 14,400 inches, equivalent to 287 feet per second. Its location was made April 29, 1873.

The Castro Ditch derives its water at the junction of Old and Kern Rivers, in the northeast quarter of section 26, T. 29 S., R. 27 E. It is 16 feet wide on the bottom, 2 feet deep, and 5 miles long. It crosses Panama Slough, and irrigates a small amount of land east of that channel. The appropriation is 1,000 inches, equivalent to 20 cubic feet per second.

The Stine Canal, belonging to the Stine Canal Company, has its headgate also at the junction of Old and Kern Rivers, adjoining that of Castro, in the northeast quarter of section 26, T. 29 S., R. 27 E. It occupies the bed of Old River for the distance of half a mile. This canal is 80 feet wide on the bottom, 3 feet deep, and 15 miles long. It has two main branches, with numerous forks, varying in width from 12 to 20 feet on the bottom, and having an aggregate length of 32½ miles, and 41½ miles of distributing ditches. It is next in importance, in this system, to the Kern Island Canal, and shares with the Farmers' Canal in irrigating T. 30 and 31 S., R. 27 E., besides supplying water for other lands west and south. Its appropriation is 55,980 inches, equivalent to 1,117 cubic feet per second. It was located December 12, 1872.

The Anderson Canal heads also in the northeast quarter of section 26, T. 29 S., R. 27 E., at the junction of Old and Kern Rivers. Its headgate connects with those of the Stine and Castro, and the same system of wing-dams serves for all. The canal runs southwesterly 4 miles, is 15 feet wide on the bottom, and 2½ feet deep. This canal is used exclusively for irrigating Stockdale ranch, located about 5½ miles southwest of Bakersfield. Its appropriation is 5,057 inches, equivalent to 101 cubic feet per second. The location was made October 9, 1872.

The Gates Canal, owned by the Gates Canal Company, is taken out of Kern River, in the southwest quarter of section 26, T. 29 S., R. 27 E., and runs in a southwesterly direction 2½ miles. It is 12 feet wide on the bottom and 2½ feet deep. It also is used exclusively in irrigating Stockdale ranch. Its appropriation is 5,057 inches, equivalent to 101 cubic feet per second. This canal was located originally without record early in 1872, and relocated October 7, 1878.

The Buena Vista Canal belongs to the Buena Vista Canal Company. Its head-gate is in the northeast quarter of section 33, T. 29 S., R. 27 E., and runs southwesterly through Bellevue ranch, located about 8 miles west of Bakersfield. It is 13¾ miles long, 30 feet wide on the bot-

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tom, and 3 feet deep. It has numerous ditches of various dimensions. Its appropriation is 14,000 inches, equivalent to 279 cubic feet per second. Its location was July 15, 1870.

The James Canal, which is the property of the James Canal Company, heads in the northeast quarter of section 33, T. 29 S., R. 27 E. It runs southwesterly 17¼ miles, is 60 feet wide on the bottom the first 3 miles and 40 feet the remaining distance, and is 3 feet deep. This canal also flows through Bellevue ranch, supplying water for this ranch and all lands still farther south and west. The amount of appropriation is 19,730 inches, equivalent to 394 cubic feet per second. Date of location, October 15, 1871.

The Plunkett Canal, belonging to the Plunkett Canal Company, commences in the northwest quarter of section 33, T. 29 S., R. 27 E. It runs southwesterly through Bellevue ranch, and is used exclusively for it. Amount of appropriation is 5,057 inches, equivalent to 101 cubic feet per second. Date of location, December 31, 1872. It is 3¾ miles long, 12 feet wide on the bottom, and 2½ feet deep.

The Meacham Canal is the property of the Meacham Canal Company, commencing in the northwest quarter of section 6, T. 30 S., R. 27 E., and flows through Bellevue ranch southwesterly about 4 miles. It is 12 feet wide on the bottom and 3 feet deep. Its appropriation of water is 1,500 inches, equivalent to 30 cubic feet per second. It was located April 15, 1873.

The Wilson Canal commences at a point on Kern River, near the head-gate of the Meacham Canal, in the northwest quarter of section 6, T. 30 S., R. 27 E., and also flows through Bellevue ranch 2½ miles in a southwesterly direction, and is 5 feet wide on the bottom and 2 feet deep. It appropriates 500 inches, equivalent to 10 cubic feet per second, and was located August 15, 1874.

The Henley Canal begins in the southeast quarter of section 9, T. 30 S., R. 26 E., and runs southwesterly 2½ miles. It is 3 feet wide on the bottom and 2 feet deep. The amount of the appropriation is 2,880 inches, equivalent to 57 cubic feet per second. Its location dates January 29, 1874.

The Frazer Canal takes its waters out of the Kern River, in the northeast quarter of section 16, T. 39 S, R. 26 E. It flows southwesterly 2¼ miles, and is 5 feet wide on the bottom, with a depth of 1½ feet. It appropriates 2,600 inches, equivalent to 52 cubic feet per second. It was located April 15, 1873.

The Kern Valley Water Company has two main canals for the reclamation of swamp land in District No. 21, in Buena Vista Slough, and a distributing canal. The principal canal is that on the west side of the district, following, generally, the border of the swamp lands for a distance of 24 miles. At its head it is 125 feet wide on the bottom, 7 feet deep, with sides sloping from 3 to 1 and from 7 to 1, and a grade of nine-tenths of a foot per mile. The grade is very irregular, and we give it in detail. For one-half mile the grade is nine-tenths of a foot; 9 miles, it is 2 feet; one-half mile, $2\frac{5}{10}$ feet; and 1¼ miles, level; vertical drop, $1\frac{6}{10}$ feet; 1 mile, 8 feet; 2 miles, level.

Below this main channel, a parallel distributing canal, 30 feet wide on the bottom and 2 feet deep, was constructed about 10 miles long. On the east side of the swamp a canal about 6 miles long was constructed for irrigation purposes, having a width on the bottom of 25 feet, a depth of 3 to 5 feet, and side slopes of 3 to 1. The appropriation of water of the Kern Valley Water Company is 100,000 inches, equivalent to 1,995 cubic feet per second, and its location dates April 7, 1877. The

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appropriation of the Kern Valley, east side, is 30,000 inches, equivalent to 599 cubic feet per second, and the location dates April 9, 1877.

Résumé of the canal system of Kern Valley.

Name of canal.	Length.	Appropriation.	
	Miles.	*Miner's inch.*	*Cubic feet.*
Beardsley	8	47,230	938
McCord	14½	5,000	100
Calloway	32	74,000	1,476
McCaffry	3	1,296	26
Emery	3	2,000	40
Jones Tuckey	4	1,000	20
Railroad	⅜	31,075	620
Wible	½	5,040	100
Goose Lake	4½	90,000	1,795
Pioneer	11½	20,074	400
Edwards	2	1,440	29
James and Dixon	3	14,000	279
Johnson	4	8,640	172
Ashe	1	1,200	24
May	2	4,000	80
Joice	4	6,250	125
Dixon	2½	3,456	69
Total	99¼	315,701	6,293
Kern Island	30	20,000	400
Old South Fork	3	3,800	75
Farmers'	19½	14,400	287
Castro	5	1,300	20
Stine	47½	55,980	1,117
Anderson	4	5,057	101
Gates	2½	5,057	101
Buena Vista	13½	14,000	279
James	17½	19,730	394
Plunkett	3½	5,057	101
Meacham	4	1,500	30
Wilson	2½	500	10
Henley	2½	2,880	57
Frazer	2½	2,600	52
Kern Valley Water Company	40	130,000	2,594
Total	197½	281,561	5,618
Grand total	297⅞	597,262	11,911

The rains of winter and the melting snows of summer on the upper Sierra thus maintain a full flow in Kern River for about two-thirds of the year, the period covering the greatest demand for irrigation. Kern River has a slope through the valley of 6 to 8 feet per mile, and lies in a shallow, sandy bed, with banks of sandy soil 3 to 6 feet high. These are favorable conditions, and enable water to be taken out at almost any point at comparatively small cost. Few permanent, costly dams, or very expensive head-works have been found necessary; a simple wing-dam of sand and brush, running out into the channel of the river at an acute angle up the stream, serves every purpose, in most cases, for diverting water into the canals, there being only five weir extensions across the river in the whole system.

Then, again, the slope of the irrigable lands of the valley is so great there is no difficulty in running canals in almost any direction over them, nor in distributing water in the smaller ditches, or in draining it off. It is therefore peculiarly favorable for irrigation, yet the soil is too friable to permit of canals of any considerable size taking the natural slope of the ground without serious erosion and damage.

The grade over these sloping plains is regulated by "drops" or weirs, placed at proper intervals, with movable weir-boards, which are also convenient and necessary for raising water to enter distributing ditches.

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These drops are constructed similarly to the canal head-works, and are characterized by an absence of ponderous gates for regulating the water and extreme lightness of timber used, studying the greatest economy in material. Head-gates are a necessity when the water is taken out of the river to control the admission of water to the canal. They are made entirely of wood, there being no stone readily accessible in this vicinity. The better class of these head-gates are constructed upon a foundation of anchor-piles driven into the sand as far as possible, with sheet-piling of 2-inch planks at the upper and lower sides of the structure.

Weirs, as before indicated, are constructed not only for drops, but for raising water for entering distributing ditches. Side gates are at the head of distributing ditches for the purpose of admitting water from the canal into such ditches. They are constructed upon the same principle as head-gates.

The canal flume is the usually constructed flume for carrying one stream of water over another across a gulch or ravine.

Wing dams are built of brush and in the river, from the lower side of the mouth of the canal up the stream, at an acute angle with the current, to turn the waters of the river into the canal.

Waste-gates are built at the heads of canals and also along their course to let off any oversupply of water. Inverted siphons are put into canals for the purpose of carrying their waters under another canal.

A module is put into a gate or other structure for the measurement of water.

There are four general classes of irrigation as conducted in California.

First method.—Constituting irrigation of vines and trees, as practiced in some portions of Los Angeles and San Diego counties, under which the water is conducted through pipes having openings at each different vine or tree to be irrigated, all of these small distributing pipes being supplied from one large pipe. This of course is a highly expensive mode of irrigation, and one which can not be practiced except where an exceedingly small amount of water must be utilized to the greatest degree possible and where the results as derived therefrom are of great benefit.

Second method.—By building ditches at stated distances apart, the land being irrigated by the seepage or percolation of water through the soil, from one ditch to another. This method is applicable only in districts having a loose soil, through which the water can easily pass, and is not to any extent valuable for use in Kern County, where such conditions do not exist.

Third method.—By building the ditches on the ridges or highest ground in the land to be irrigated, and from them running the water downhill and holding it back by means of small temporary checks, or, in cases of vines or trees, running the water downhill through plow furrows. This method of irrigating is well adapted to the irrigation of orchards and vineyards, thereby utilizing the water to good advantage; but in the irrigation of grass or alfalfa land, or in other cases where it is desirable to cover simultaneously a large area of land, it has been found to be more expensive than, and in the irrigation history of Kern County, has generally been supplanted by, the fourth method.

Fourth method.—By building ditches at stated distances apart, running downhill with the slope of the country, and between them building permanent levees on contour lines, the latter being distributed with the grade at varying distances of fall, as desired, of 6, 9, 12, 18, or 24 inches.

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This is the cheapest method of irrigating where there is an abundance of water and where the area owned, controlled, or irrigated by any one man is large.

The above descriptions under the first, second, and third modes of irrigation clearly indicate the manner in which the water is handled, and to the uninitiated no explanation is therefore needed, except as connected with the fourth mode, which has most generally been adopted in Kern County. In the second, third, and fourth modes of irrigating the diversion of the water from the river, creek, spring, reservoir, or other general source of supply where large areas are to be irrigated is required to be made into one general conducting ditch, from which the smaller distributing ditches diverge, conducting the water to the lands to be irrigated.

DIFFERENT SYSTEMS.

Subsoils dams are frequently constructed in California with the object of cutting off the subterranean flow of water in channels whose beds soon become dry on the surface. It is first ascertained by sinking shafts across the channel whether water is thus passing subterraneously. This will be observable in some cases by floating substances traversing the shaft, but if the flow is very slow it may not be detected by this means, and coloring the water with a dye will show it by a replacement of the colored by pure water passing through the shaft. A subterraneous water flow is frequently brought to the surface by impervious strata traversing its course. Localties in which this occurs are the best sites for weirs. It is not probable that such natural bars are to be found in the plains, far removed from the source of supply, and to produce them artificially in such situations would necessitate very deep and probably very extended walls. The trial shafts should therefore be made where the valley is well defined in character.

Of course these submerged dams can only bring water to the surface of the channel where the latter is of sand or gravel through which the water would rise, forming an artesian supply. Where the surface of the bed is of sand, in which the water could be again lost, the elevated water would of course be diverted to an impervious channel provided for it. Where such subterranean water can be intercepted a considerable supply might be expected for some months after the water ceased to flow previous to the interception, for doubtless in many cases a considerable proportion of the rain-fall is absorbed and given off gradually to subterranean strata.

Subterranean currents have also in several instances been interrupted by means of tunnels run in from the surface 2,000 and 3,000 feet, the flow being planked to form a flume and the water then conducted to open channels. Tunnels of this character are at Ontario and at Passadena, where a second tunnel was driven at a higher level, completely cutting off the supply from the first enterprise. At Riverside it has been ascertained that there is a large subdrainage in the low land forming the bank of the river. A level channel for half a mile, cutting across this drainage so that the flow shall be intercepted, will give perfectly clear water, sufficient for the canal supply. Should half a mile not be sufficient it can be extended.

Flumes are used where it would cost considerably more to convey water in an excavated channel, or where the soil is gravelly, and the loss by percolation would be great. Ravines are crossed by flumes or pipes. The objection urged against flumes is their continual cost for repair, and danger of destruction by fire. Where they are used, and practicable,

they are set on a heavier grade than channels 30 to 35 feet per mile, and are of proportionally smaller area than channels with less grade. They should be constructed in straight lines if possible. Curves where required should be carefully set out, so that the flume may discharge its maximum quantity. Many canals have miles of fluming in California. In the ordinary style of construction sills, posts, and ties support and strengthen the work at every 4 feet. The posts are let into the ties and sills. The sills extend 20 inches beyond the posts, to which side-braces are nailed to strengthen the structure. Where flumes are not supported on trestles, but rest on an excavated ledge, it is desirable still to use the stringers, which should be placed just outside the posts, so that water leaking from the sides will drop clear of them. Main supports, such as trestles, are placed 8 feet apart. Planking should be either redwood or heart sugar pine.

A flume at Riverside is 900 feet long, the section being 8 feet by 2 feet 8 inches, the sills rest on concrete blocks made *in situ*, molds being over the spot where the block is required, and concrete consolidated into it. Its greatest height is 42 feet; the total cost, $6,200; waste-gate at the upper end cost $200. This is necessary in case of repairs being required. The connection with the land at either end is 15 feet long, with sets of flanges projecting 5 feet on either side, and a 16-inch plank underneath. The joints are covered with a solution of asphalt in turpentine, which is elastic and does not crack. This protection would not be necessary if carefully joined redwood were used.

A flume at Los Angeles, constructed by Mr. F. Eaton, is both economical of material and strong in design. Here Oregon timber was used. The joints were left open one-sixteenth of an inch, and chamfered, and the inside swabbed with asphalt. The planks were 16 feet long, breaking joints at 8 feet. Cattle-troughs are made on the same plan from 8 to 16 feet long.

Flumes are often constructed, instead of small channels, where the soil is porous and the quantity of water limited. These are made of three planks, in lengths about 10 feet, and butt-jointed (the joint being covered and connected by a 3-inch by 1-inch piece), and are laid to a grade of 10 feet to the mile or more. Holes are made in them opposite each tree or furrow that requires water, a stop is placed in the flume below the length to be irrigated, and the plugs removed from the holes when the water is to be delivered.

The Bear River Canal flume is 500 feet long, with section of 5 feet by 3 feet, and a fall of 10 feet per mile. Flumes are extensively used in hilly districts for drainage across the land, and a waste flume is inserted opposite the drainage, permitting the water in excess of the channel's capacity to escape. A flume is sometimes carried inside a larger one, the smaller one delivering the water at a higher level, or to another irrigator, so that the two supplies may be kept separate.

The asbestine system.—The inventors of this system hold that in a region where no rain falls during the long summer the only proper way to irrigate orchards, vineyards, etc., is to apply the water below the surface of the ground, keeping the surface dry. The asbestine system consists in conducting the water in concrete pipes below the reach of the plow along each row of trees. At each tree a plug is set in the upper side of the pipe, each plug having a small hole through which, and nowhere else, the water escapes, falling on the outside of the pipe and being taken into the soil by capillary attraction. It saves from three-fourths to nine-tenths the water used in surface irrigation. It is under perfect control, and can be applied wherever irrigation is needed.

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There is no need of summer cultivation, either before or after irrigating. The surface of the ground is always dry in summer, hence exempt from the unavoidable chill of surface irrigation. The soil is never excessively wet and can not bake, but remains moist, loose, and at nearly uniform temperature, promoting a long summer growth. Anything that the soil lacks as plant-food (manure, lime, etc.) can be easily, directly, and economically applied in liquid form. The pest of the vineyard, phylloxera, can be thus easily reached. No grading is necessary, as the system works as well on hill-sides and undulating land as on ground uniformly sloping.

If, through carlessness, muddy water is let into the pipe, and sediment collects, one or more of the lower plugs can be taken out, and the water passed rapidly through. The pipes will thus be cleaned. If the water is kept in motion, the sediment it contains should not be deposited. On the Briggs farm, in the Sacramento Valley, the pipes, 4 inches in diameter, are made on the place by an ingenious machine, from cement and fine gravel in the proportion of three-fourths of the latter to one-fourth of the former, and are laid at a depth of 20 inches down the center, between each second row of vines, with an opening for the escape of the water in the upper side of the pipe every 30 feet. The pipe-making machine is so constructed as to travel along the trench, making and laying the pipe in one operation, after which the earth is covered in with a guard over the vent-holes to prevent choking.

The water supply, raised when required from a neighboring stream by steam-engine and centrifugal pump, is commanded by sluice-doors at various points, to admit of the water being laid on or shut off at pleasure; but excellent as the system is in theory, Mr. Briggs has not yet managed to get it to work with thorough satisfaction.

Mr. Holt, of Riverside, has devised a different mode of letting the water escape from the pipes. To prevent the holes in the plugs becoming occasionally closed by roots finding their way into them, a section of about 6 inches long is cut out of the continuous pipe where the plugged hole would be, and a square hole, about 6 inches by 6 inches, sunk below the gap in the pipe. A tile, in the form of a saddle, 9 inches long, covers the gap, and the water escapes between the two surfaces. The advantage of this plan is that if roots do find their way between the two faces they are easily cleaned away by cutting them. The hole below the gap catches any silt that may pass down the pipe. This most economical system of irrigation should be especially suited to cases in which water is very scarce, as where it is raised by wind-power. The water will spread over a circular area of 16 feet diameter in four or five hours. Subirrigation is practiced largely in Japan.

Pipes and conduits.—Where water is scarce, and has to be conveyed long distances in channels excavated in the soil, exposing it to too great a loss, impervious channels and pipes of various kinds have been resorted to to convey it to land that was valueless without it. This has caused the adoption of a variety of materials to render conduits impervious and of various modes of application of water by their means. The following impervious conduits are used: (1) Wooden flumes; (2) lined channels; (3) wrought-iron riveted asphalted pipes; (4) wrought-iron laminated asphalted pipes; (5) terra-cotta pipes; (6) cemented pipes; (7) asphalt pipes.

Lined channels.—The Zanja Madre Channel at Los Angeles was lined with concrete, and had a cross-section of a segment of an ellipse, with a diameter of 5 feet and a depth of 3½ feet. The thickness of concrete was 6 inches. The ingredients were hydraulic lime, two parts; clean, sharp

sand, three parts; pebbles, 1 inch in diameter, four parts; small stones, 2 to 3 inches in diameter, four parts; large stone, not exceeding 5 inches in diameter, four parts; cost $2 per linear foot.

A tunnel conveying water to Los Angeles was lined on the bottom with concrete 4 inches thick, forming a semicircle of 4 feet diameter. The cost was 75 cents per linear foot, with cement at about $4 per cask. Wrought-iron riveted and asphalted pipes are extensively used in Los Angeles County for irrigation. They are jointed, stove-pipe fashion, and when not subjected to too great pressure are set with red or white lead.

Wrought-iron laminated asphalted pipes are made of two shells of sheet-iron. These shells are made of one sheet of iron 8 feet long, rolled and lapped 1 inch, and united by a composition solder. They are half the thickness of iron that would be necessary for the ordinary sheet-iron pipe. The inner shell is telescoped into the outer shell whilst immersed in hot asphalt, specially prepared, giving a thickness between the sheets one-sixteenth of an inch, or more, if desired, thus making an impassable barrier to corrosion from outside or inside. The outside and inside coatings are also substantial. This produces a solid shell 8 feet long, with an inner surface free from all excrescences.

The pipe is also made double, of one sheet, by rolling a sheet that is twice the width of the single sheet until the edges will lap with a thickness of iron between them; the lap is riveted. This is dipped in asphalt, but it can not have the intermediate lamina of asphalt, which is the main advantage of the laminated over the single sheet-iron pipe. Both these descriptions of pipes are jointed end to end, an inner sleeve being fixed in the shop. In laying, the end is dipped in hot asphalt and an outer sleeve is also dipped and pressed on by a clamp over the point until the asphalt is set. Bends and branches are of cast-iron, as in the ordinary sheet-iron pipe, and the joints are made with cement.

The 4-inch laminated pipe has been tested up to 500 pounds per square inch. Its price is about 25 cents per linear foot. The double-rolled pipe is about 17 cents per foot. The construction of the latter is much simpler, and the asphalt has been found a perfect protection from rust, so there is no necessity for the lamination. Terra-cotta pipes would be excluded by their price, except for some special purpose, such as sewerage or culverts, for use under roads, etc. Concrete pipes, where good sand is obtainable, and no pressure is required, are extensively used.

At Ontario Colony, San Bernardino County, an irrigation enterprise has been started, which is mainly dependent on concrete pipes for conveying the water from the cañon. Thirty miles of 12-inch concrete pipe have been laid here, at a cost of about 43 cents per linear foot for making. The ingredients are cement, sand, and gravel, in the proportion of one of cement to four of clean, sharp sand, and gravel. The gravel may be as large as half the thickness of the shell of the pipe.

The pipes are formed in molds of sheet-iron. These consist of two sheet-iron cylinders, an inner and an outer, both of which can be expanded and contracted by means of a bar fixed parallel to the joint from which four arms project, connected with the outer edge of the joint so as to close and open it. Between these cylinders is a cast-iron ring, forming the base. This cast-iron ring is shaped to mold the end of the pipe to form a socket. The inner cylinder or core is kept central at its base by being inside the cast-iron base. It is centered above by hand until sufficient of the concrete mixture has been consolidated around it to keep it so. The filling is then completed, being put in in small quantities at a time, and consolidated with an iron rammer. The upper end

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of the pipe is shaped to form a spigot by means of a cast-iron ring that is worked round by hand. A 6-inch diameter 2-foot-long pipe is made at the rate of one length per minute by three men. Only as much of the mixture must be made at one time as can be used within ten minutes after mixing, or its setting qualities will be injured. The newly-made pipe is removed from the mold or the mold from it on the drying area, the base being left for it to stand on until sufficiently set to handle. In handling the larger-sized sections a clip with handles is used, and another for laying.

The pipes made with mixture of one to four are not guarantied to stand pressure, but with a slight increase, and well consolidated, they will stand a considerable head. They are cheaper than any other pipes when suitable sand and gravel are obtainable near the site where they are to be used. A continuous pipe-making machine, for making a continuous concrete pipe in a trench excavated to the required depth for subirrigation, consists of a cylinder of the size of the pipe required, in which an india-rubber core is moved backwards and forwards by a lever, the concrete material being thrown into a funnel fixed at right angles to the pipe-making cylinder. By this means three men can make over 1,000 feet of 2-inch piping in ten hours. This system is not much used.

Asphalt-concrete pipes are made as described for concrete pipes, and are superior to them, being perfectly impervious and capable of withstanding much greater pressure. The proportion of sand to asphalt and the other ingredients could not be ascertained, but the quantity of the sand need not be limited, as in cement concrete, for the larger the quantity of sand used the harder and better the pipes. The pipes are united by heating them so as to form a continuous pipe, as strong at the joints as in another part. Where the ground is yielding they are laid on piles driven 6 feet into the ground, and a plank laid on top of the piles upon which the pipe rests.

The Highland Park Water-Works, Los Angeles, for irrigation and domestic supply.—The source of the supply is the Arroyo Seco, a torrent which runs a few days only after each rain-fall, and springs, yielding during the dry months about .08 cubic feet per second. There are 400 acres supplied by the system, which must necessarily depend for its irrigation on the flood flow; hence a storage reservoir is necessary of sufficient capacity to store the rain-fall as it occurs, to be applied to the land during the intervals of dry weather, which through the rainy season average about fifteen days each. Allowing 2 inches depth as the minimum for each irrigation, 400 acres would require eighteen and one-seventh million gallons. The reservoir capacity is 20,000,000 gallons, and is connected with the main pipe, so that any excess over the distribution flows into the reservoir, and of course when the supply from the source is less than the pressure from the reservoir the distribution receives the water from the latter. The reservoir is therefore the head to which the supply pressure is due unless the reservoir main valve be closed, when the head at the source would furnish the pressure.

This system is capable of supplying 12 inches depth of water over the 400 acres during the year, in addition to the rain-fall, which averages 12 inches, and falls between the months of November and May. The land thus receives 24 inches depth of water, which is ample in this country for most products required, excepting oranges and alfalfa. The main pipe is 8 inches in diameter, asphalted wrought-iron, and the distribution pipes are of the same material, and from 2 inches to 6 inches in diameter. Each lot takes its supply through a 2-inch pipe. The

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effective pressure is 40 pounds per square inch. The land is irrigated by furrows, and service-pipes are laid over the ground in some cases, so that each tree can be watered from a rubber hose into a check of from 5 feet to 12 feet diameter, according to the age of the trees.

The head works are temporary, consisting of a wooden trough 100 feet long. This is laid in the bowlder-bed of the channels, with the top of the sides slightly below the bed line. It is anchored by cleats fastened to its bottom, that extend 3 feet from the sides. These are covered, and the trough filled with bowlders, the water flowing between the bowlders. The trough at its lower end is connected with a 10-inch cement pipe. The temporary wooden flume will be replaced by a perforated wrought-iron pipe that will extend 100 feet, 5 feet below the shingle and bowlder bed, the water being dammed back by a submerged weir, causing the water that the pipe is capable of carrying to be drawn off by it; the water will thus be filtered of anything that can now pass between the bowlders. The cost of this scheme was $21,300.

The Ontario colony.—This colony is an example of utilizing waste land and water to the maximum of benefit. It is situated on the sloping land from the foot-hills of the Sierra Madre Mountains, where San Bernardino and Los Angeles Counties join, the San Antonio Cañon or Valley giving a perpetual supply of water from the mountain snows in the summer, and from rain which falls on the lower slopes and hills in the cold months. The soil was analyzed and examined as to its productive capability, and found to be peculiarly adapted for the growth of vines and fruit-trees. The climate was also favorable. Having purchased the land and the water rights, the colonists distributed the water by means of cement pipes over the whole tract, divided into 10-acre lots, so that each lot should be supplied at the highest point. To accomplish all this has cost about $170,000. This includes roads, streets, railway station, hotel, college, dam, and 27 miles of pipes, masonry-lined channel and tunnel, iron pipes for supply of township, etc.

A dam diverts the surface water from the channel, but as a large quantity passes below the bed, a tunnel 3,000 feet long has been driven across this drainage and leads it into a masonry-lined channel, which is 6,000 feet long. The water is taken from this channel by the cement pipes, but a reservoir will be constructed to store the surplus water not required during the non-irrigating season, and the pipes will then connect with it. It is intended here to use the laminated wrought-iron pipe, preferring it to the single-shell riveted pipe. The water is delivered and measured from the cement pipes by means of a vertical connection, at which point a valve is fixed, consisting of a cast-iron plate, with an aperture the size of the pipe in it, and a groove for the valve to slide in. This valve is simply a plate of cast-iron with a wrought-iron lifting-rod. The tunnel referred to was decided on after sinking experimental shafts across the valley and then ascertaining that there was such a subterranean flow that a light substance, such as a chip of wood, would be carried to the bottom of the shaft.

This mode of intercepting water has been frequently resorted to with the most surprising results. The quantity of water used for irrigating by the pipe system is 1 cubic foot of water per second to every 50 acres. The value of 1 cubic foot of water per second where it can be applied, as here, to fruit-growing, is estimated at $50,000. The unit of measure is one-fiftieth of a cubic foot, and is termed an inch of water, and is measured by the discharge through an aperture 1 inch square in

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a 1-inch plank under a 4-inch pressure. The discharge of a stream for irrigating purposes is estimated for the mid-summer period, that is from the 15th of July to the 1st of August, when it is at its lowest.

LAKE HEMET WATER COMPANY, SAN DIEGO.

District and work.—The general project of the Lake Hemet Water Company contemplates the storage of water in Hemet Valley for supply to the stream at time of low flow, and the diversion of such waters, together with other waters of south fork, from a point just above the mouth of Strawberry Fork, and conducting them by means of pipe line for the irrigation of lands at the head of San Jacinto Plain, in the valley below the lands of the Fairview company. The district commanded is, practically, nearly the entire San Jacinto Valley.

Delivery and distribution works.—From a temporary diverting dam of brush in the south fork of the San Jacinto River, at the point above indicated, a 21½-inch sheet-iron pipe conducts water several hundred feet to a large sand-box, arranged in various compartments; thence the main pipe, 13 inches diameter, extends down the bed of the cañon a total distance of 16,091 feet, to a relief box, into which it empties freely at an elevation of about 500 feet below its head. From the reilef box a 22-inch riveted iron pipe extends to a point beyond the mouth of the cañon, a distance of about 10,250 feet. For purposes of temporary supply, an 8 inch pipe has been laid thence, a distance of 22,790 feet, to about a central point in a tract of 10,000 acres, owned by the Hemet Land Company, which is an associate organization with the Lake Hemet Water Company. But it is intended to replace this 8-inch pipe by an extension of the 22-inch pipe at an early date. The total length of pipe thus far laid, including some 5,000 feet of lateral distribution pipe, is about 54,900 feet, or nearly 10.4 miles. The weight of iron used has been from No. 16 up to No. 12 in thickness, and the total cost has been about $45,000. The pipe-laying down the cañon of the river proved to be a tedious and expensive job, for the reason that a succession of large boulders was encountered in the trench, many of which had to be blasted, and many removed with derricks and powerful pulleys, and for the further reason that the bed of the creek had to be crossed four times.

Storage reservoir; Hemet Valley.—The main resource of the company in the way of water supply is to be the projected reservoir of Hemet Valley, 20 miles above the town of San Jacinto, at an elevation of 4,300 feet. The south fork leaves the valley through a cañon, only about 60 feet wide at the bottom, with walls of granite, vertical on one side for 100 feet in height, and on the other sloping at a very steep angle. At a height of 120 feet above the base, at the most favorable dam site, the width across the cañon is but 200 feet, and at 150 feet, it is less than 300 feet. Granite of the best quality is at hand; sand, sharp and clean, may be had convenient; an abundance of pine timber is growing in the valley and on the hills all about the site, and water, whose power may be utilized for much of the work, is flowing in the stream. Taking all these convenient materials and facilities, and the character of the dam site into consideration, there are few localities in the State more favorable for the construction of a high-storage dam. The reservoir basin is a capacious one, but not notably so, as the following table of contents, at successive levels, will indicate:

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Elevations of water plane.		Corresponding areas of reservoir surface.	Capacity of reservoir above base of dam.	
Above base of dam.	Above lowest outlet.			
Feet.	*Feet.*	*Acres.*	*Cubic feet.*	*Mill. gallons.*
30	*10	*.37	112,000	.84
40	20	*2.70	1,769,00	13.23
50	30	12.50	5,342,500	40.06
60	40	27.94	14,155,000	105.88
70	50	50.45	31,232,000	233.62
80	60	90.61	61,953,000	463.41
90	70	115.96	111,947,000	837.35
100	80	176.76	175,708,500	1,314.40
110	90	238.70	266,197,500	1,991.16
120	100	349.80	389,374,000	2,911.62
150	130	.....	.....	†6,000

*Figures in this column are approximations only. † Approximation.

SAN DIEGO RIVER WORKS AND PROJECTS.

The commanding position occupied by the works under construction by the San Diego Flume Company, their far-reaching design in accumulating from different sources the waters of distant streams, their costliness, the wide extent of the district commanded, and the fact that they terminate at the city of San Diego, which may receive its supply at high pressure on the summits of its greatest elevations, render them in many respects more important to the prosperity of the region than any other.

District and works.—As far as they have been outlined the works consist of a storage reservoir on the headwaters of the Bowlder Creek tributary of the San Diego River, a diverting dam of masonry in the river proper, and a line of flume 36 miles in length—skirting the cañon's side for 21 miles, then circling south of the valley of El Cajon, and finally emerging upon the mesa 10 miles east of the city of San Diego. The plans of the company contemplate the diversion of the headwaters of the Tia Juana and Sweetwater Rivers on the south, and the San Dieguito on the north, into the head of the main flume, the construction of various additional storage reservoirs in the mountains, and a distributary reservoir at the end of the flume, the development of tributaries of the San Diego by tunnels under their beds and gathering them into the main conduit by smaller lateral flumes, and the distribution of the water from the end of the main flume by pipe lines over the mesa.

Storage reservoir.—The main dependence of the works for a summer and fall supply is at present the Cuyamaca reservoir, located 43 miles northeast of San Diego in the Cuyamaca Mountains, at an altitude of 4,500 feet. The water-shed of this reservoir is about 15 square miles in area, draining two of the highest peaks of the range. The reservoir is formed by an earthen dam 635 feet long on top, 40 feet in height, thrown across the outlet of a broad, flat mountain valley. From the eastern rim of the water-shed the country drops abruptly into the desert. The hills on this side are low and barren. The two Cuyamaca peaks on the west are clothed with forests of pine and oak.

Cuyamaca dam.—The site of the dam was one which had all the surface indications of solid rock. The whole surface was covered with loose granite bowlders, and before sinking test pits, preparations and plans had been made for building a masonry dam. The excavation for foundation developed a bed of clay instead of bed-rock as anticipated, and an abundance of good clay being found in the immediate neighbor-

hood, the plans were changed and an earth-work dam built. A puddle trench was cut under the center of the embankment, and the clay filling built up in layers. The embankment has a base of 115 feet, inside slope of two to one, outside slope of one and one-half to one, top width 15 feet. The high-water mark is fixed at 5 feet below the top, at which point a waste-way 50 feet wide is placed on one side. The water-face of the dam is covered with stone riprap laid, dry, 8 inches in thickness.

The outlet culvert is of masonry 3½ feet wide by 4 feet 6 inches high inside, 120 feet long, its bottom placed at the level of the original surface with a fall of 3½ feet in its length. At the upper end it opens into the base of a circular brick tower 8 feet in diameter outside, 5 feet in diameter inside, and carried to the level of the top of the dam. This tower is provided with two gates of wood, closing openings 3 feet wide by 4 feet 6 inches high. The lowest opening is at the bottom of the tower, the second 15 feet 9 inches higher, immediately above the lower. These gates slide up and down in wooden grooves, and as they are to be moved by chains or ropes, are not convenient, particularly when they are to be closed quickly under pressure. An iron gate is provided inside the tower to close the head of the outlet culvert.

Diversion and delivery works.—The diversion is made from the San Diego River about 31 miles from its mouth, at an elevation of about 800 feet above sea-level, and where the stream, falling at the rate of about 30 feet per mile, is in an open cañon flanked by barren mountain slopes rugged and steep.

San Diego diverting dam.—The diverting dam is built of masonry of of the following dimensions: Maximum height, 34.5 feet; length, 447.5 feet; width at top, 5 feet; up-stream batter, 1½ feet in 20 feet; back batter, 7 feet in 20; width at base, 18 feet. The dam contains 4,000 cubic yards of masonry, and required 2,410 barrels of cement. The average depth of excavation in the bowlders that formed the bed of the stream was 10 to 12 feet, and the foundation rests upon the soft, disintegrating granite, forming the bed-rock of the country. This material may be readily cut with the pick and crumbles on exposure to air. After the dam was completed and tested, the leakage was considered excessive, and the upper face was again stripped to the foundation, and an apron of masonry 2 feet thick was sunk to a depth of some 6 feet lower than the original base. The wall was then repointed and partially plastered on the face. The top of the dam is at an altitude of 813.5 feet. In alignment the dam has an angle in the center whose apex is pointed up-stream. Otherwise the structure is straight, depending upon the weight of its mass for stability.

The head of the flume passes through the wall with wooden gates to control the water. The level of the flume-bed is 9 feet below the top of the dam, or 4 feet below the overflow weir. The main waste-weir is 210 feet long, with a secondary weir 20 feet long. The floor of these weirs is of pine plank spiked to timbers that are bolted to the masonry. In addition to the overflow waste-weirs, there are two culverts passing through the dam for draining the basin above. One of these is 2.5 feet square, 7 feet below the grade of the flume, the other 3 feet square, 8 feet lower than the first.

Main conduit; flume line.—The flume is set on a bed cut in the mountain side, except where it is supported on trestling. All fills are made with loose rock laid with some care on the outer face. Its total length is 36 miles. The grade is 4.75 feet per mile.

Tunnels.—There are eight tunnels upon the work, lined with masonry on the sides, timbered overhead, except in solid rock, and plastered

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with cement on bottom and sides, of a total length of 4,168 feet. The tunnels are finished 6 feet wide by 6 feet 1 inch high in the clear. In loose material the sides are walled up with masonry 12 inches thick to a height of 4 feet, on top of which rests timbering, 6 by 8 inches, with lagging of 3-inch plank; the bottom and sides being finished smoothly with cement.

Flume.—The flume is made in rectangular form, 5 feet 10 inches wide by 3 feet 10 inches deep, in the clear. The bottom and sides are of 2 inch redwood plank, planed on the inside. The frames, placed at intervals of 4 feet, consist of a sill 4 by 6 inches by 12 feet, two posts 4 by 4 inches by 4 feet, and two diagonal braces 2 by 4 inches, 3 feet 3 inches long. The substructure where it rests on the ground consists of mud-sills of redwood, 2 by 12 inches by 9 feet, two stringers 4 by 6 inches, one under each side of the flume box, and a block 8 inches long supporting the sill in the center. Where on trestle, the sills of the flume rest on three longitudinal stringers, two of which are 4 by 12 inches, and one in center 6 by 12 inches. The trestle bents are placed 16 feet apart, and for trestles up to 20 feet in height, consist of two posts 8 by 8 inches set on a batter of one to six, a cap 8 by 8 inches by 6 feet, a sill 8 by 8 inches of proper length, and two diagonal sway braces 2 by 10 inches. For higher trestles, more posts are introduced, and trussed bridges carry the flume over the deepest gorges that are crossed. Ten million feet of timber will be consumed in the structure. The flume has a theoretical capacity when filled within 3 inches of the top of 110 cubic feet per second, or about 5,500 miner's inches. The flume for its full length of 36.6 miles is now carrying water, with sideboards 16 inches high; the remaining boards for full completion are to be added later.

Distribution system; pipes and reservoir.—From the end of the flume to San Diego the main pipe line will be 9 miles in length to the top of the mesa overlooking the city. A branch pipe 1 mile in length will deliver surplus water to a reservoir to be constructed for storing the unused delivery. A main 4 miles long will be required to tap this reservoir and join the through line below. This reservoir is called the city reservoir, and will have a capacity of 761,000,000 gallons, covering an area of 100 acres. It will be formed by a masonry dam 50 feet high, located in a narrow gorge through blue trap rock, whose width at a height of 30 feet is but 50 feet. Its elevation above sea-level is 460 feet at the base.

BEAR VALLEY LAND AND WATER COMPANY'S WORKS.

Bear Valley and Bear Creek.—Immediately north of the San Bernardino Peak and Grayback Mountain, extending in an easterly and westerly direction, at at elevation from 4,500 to 5,000 feet, lies the valley of the upper Santa Ana River. Overlooking this and bordering it on the north is a long rugged mountain ridge, whose crest-line holds 7,200 to 7,700 feet of altitude. Next north of this, with its axis in the same direction and about 4½ miles from the main mountains on the south, we find Bear Valley, a remarkably large and flat mountain basin, about 6,200 to 6,300 feet above the sea, and 21 miles in a straight line from San Bernardino.

Storage reservoir.—This valley has the appearance of once having held a lake whose waters, at an elevation of 125 feet above its bottom, overflowed at the east end into the head of a cañon which leads away into the Colorado desert. Now, however, we find a deep and narrow rock-bound gorge leading out of its other extremity, and, cutting south-

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erly around the west end of the Central Mountain ridge, before mentioned, joining the cañon of the Santa Ana River about 10 miles above its outlet into San Bernardino Valley. This gorge holds Bear Creek, at whose point of departure from the valley a dam has been built, whereby the basin has been made, or remade, a lake.

The bottom plane of the valley is 12 miles long, and varies between a few hundred yards and a mile in width. Its lower end was narrow and rock-bound; then, a couple of miles or more above the dam site, it opened out into a couple of beautiful meadows, whose level plains, 700 to 800 acres in area, were 30 to 45 feet above the outlet; and at the upper end of the valley is another such flat, covering about 800 acres, and 20 to 30 feet still higher. At 60 feet of elevation above the base of the dam a water-plane would reach 5.9 miles up the valley and have an average width of .6 of a mile, covering 2,252 acres in area. At 120 feet of elevation the length would be 11.5 miles, the mean width 1.1 miles, and the area submerged 7,850 acres.

Water-shed and precipitation.—The water-shed tributary to this valley is 40 to 45 square miles in area. On the south lies the central ridge already described, and heavily timbered on its slope towards Bear Valley. North and west is a well-timbered, but not abrupt, mountain 1,000 to 1,500 feet above the valley. Northeast are rolling hills, 500 to 700 feet above the valley, and sparsely timbered; while the east end is closed in from the desert slope by a comparatively barren range of hills, whose altitude ranges from 200 to 500 feet above the valley.

The rock of the country is, for the most part, granite, of which huge bowlders and massive ledges crop out around the slope, particularly near the western end. Limestone is found near the eastern end, and some good lime has been there burned. Although the country is much broken and shattered in its rock formation, there is a good layer of soil over most of it, and the bottom of the valley itself is well clothed in this respect, as attested by the rich meadows which ordinarily remain moist and green the year round—receiving little streams from the wooded hillsides, and having some springs along their margins. It was feared in some quarters that the reservoir would not hold water—that it would escape in enormous quantities through the rock rifts and seams. But this fear has proven groundless.

Bear Valley is in the midst of the heaviest down-pour belt in southern California. The clouds collect around and bank up against the high peaks of San Bernardino and Grayback, and spread over into the Bear Valley water-shed. Holding so great an altitude, its precipitation is largely received in the form of snow, which in the wooded and shaded portions of its sides lies for several months. The data of local rain-fall will be given in a division of this report devoted to water supply in southern California.

Bear Valley dam.—The dam is at the extreme western end of the valley, at the head of the narrow, rock-bound gorge, which drops rapidly away. Founded on granite, where the channel was 60 to 75 feet wide, and abutting against granitic mountain sides, at the top line it is about 300 feet in length, in the form of an arch, having a radius of 335 feet; and it is 64 feet in height from extreme base to top of coping.

In cross section it is remarkable. The top is but 3 to 3.2 feet wide; the lower face vertical for 48 feet, and the upper face battered so that 48 feet down the structure is 8.5 feet thick. At this plane there is an offset up and down stream—the dam increases in thickness to 12 or 13 feet—and thence has a slight batter on both faces, so that at the extreme foundation it has a thickness of 20 feet.

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This structure is of granite, rough ashlar masonry on both faces, and broken coursed rubble in the interior, all laid in a cement mortar and grouting. The square stones show dimensions ranging from 3 to 5 feet in length, 1½ to 2½ feet in width, and 1 to 2 feet in thickness, with others, of course, smaller. Its total volume is about 3,300 or 3,400 cubic yards.

At the time construction commenced, in the fall of 1883, there was no water running out of the valley, and but little was encountered in sinking 3 or 4 feet for the dam foundation, so that small difficulty was had in this work. That season the wall was brought up to the level of the bench, 16 feet above the extreme foundation plane, for about half of its length. It was desired to make some show of impounding water the first year and to test the water-producing capacity of the shed; so a temporary earthen dam was put across the valley just below the wide marshes, about 2 miles above the main dam site. This embankment was 5 to 6 feet high and was calculated to bank water over 500 to 600 acres to an average depth of 3 or 4 feet. The move was quite a fortunate one, for the water thus held back during the winter of 1883–'84 furnished a supply, which, being gradually let out from this temporary reservoir, during the summer, enabled the constructors to keep a lake surface of sufficient depth and extent behind the new wall to afford, by means of flat-boats, an economical way of transporting stone from the quarries.

The rock was quarried from the outcropping masses of granite along the edge of the valley and near the level of the proposed lake, from 100 yards to three-quarters of a mile above the dam-site. That for the first season's work was obtained near at hand and delivered on sleds, but that for the second season's work, comprising the great mass of the dam, was transported on flats and put into the work by means of derricks on large rafts floated close against the upper face of the wall.

At the north end the dam foundation was cut into the loose, sloping mountain side, to a bed-rock base. The south end abuts against a massive, nearly perpendicular ledge or point of granite standing near 100 feet out into the cañon. This point in reality forms a part of the dam. Over it a flood escape-way has been cut 20 feet in width, and with a plane 8.5 feet below the level of the extreme crest of the dam coping.

Through the bed-rock immediately below the foundation plane, about one-third of the length of the structure from the southern end, about 9.5 feet above its extreme base plane, is a cutting which forms a culvert 3 by 3.5 feet in aperture, opening out below into a masonry pool, from which it was expected to measure the water over a weir. This culvert gradually becomes narrower towards the upper end. On the upper face of the structure the culvert is closed with masonry to a gate opening of 20 by 24 inches, over which is an iron sliding gate on brass bearings, worked by a screw at the top of an iron rod, which extends up through the water in a 6-inch lapwelded pipe, serving as a guide, to a wooden platform built out from the coping of the dam. Subsequently this culvert opening was lined over a movable mold with concrete, so that the opening is now 2 feet by 3 feet, with an arched top. There is no gate tower; no provision for drawing water at less pressure; no safeguard or regulator on the one outlet provided other than the one gate.

In the matter of abutment, the dam for about 20 to 30 feet at each side is gradually made thicker, so that it rests against the rock of the country at 1.5 to 2.2 times its normal thickness. The coping stones are 3 feet long, generally 1½ feet thick, and 2 to 2½ feet wide, resting lengthwise across the top of the structure. The finish work and coping stones have not been put on for the full length, so that for more than half the length the top is 3 to 4 feet below the intended plane of completion.

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The first year after construction, with the water plane at 40 to 45 feet, there was a little leakage at the south end, near or under the base, which it is claimed came through rifts through the granite point against which the structure there rests; and there was a remarkably free sweating and efflorescence of lime on the lower face over the whole structure, nearly up to the water-line. It is understood that the sweating phenomenon has now to a great extent ceased. There has been some expansive movement to the structure—attested by the reported fact that the cope stones which do not extend all the way across show a separation at some of the joints, to be accounted for only as the result of expansion and subsequent contraction. Otherwise the structure appears to rest just as placed, and thus far serves its purpose; the water having been for a time within a foot of the finished part of its top, and having constantly stood well up on it for a considerable period, as hereinafter written.

The company, desirous of securing greater reservoir capacity, has in contemplation an enlargement of this work. Indeed, it is proposed to provide for storage to the 100-foot plane above the present foundation, which, successfully and permanently done, would make this a truly notable reservoir and very valuable property. There have been no plans or definite ideas, even, as yet put forward for the enlarged work. Engineers familiar with such construction will see that, under the circumstances, it is a problem not without much embarrassment and grave responsibility.

Reservoir space and water-supply.—The reservoir site was surveyed preliminarily by the State engineering department in 1880, and it was reported that a dam 45 feet in height would impound water over an area of about 1,500 acres, to a volume of about 650,000,000 cubic feet, and that a dam 60 feet in height would create a reservoir space about 2,300 acres in area, and about 1,850,000,000 cubic feet in volume. The dam subsequently built is not exactly at the location where the section of 1880 was made, so that the figures of the latter and more detailed survey made by the Bear Valley Company do not tally precisely with those of the preliminary reconnaissance, but they are close enough to prove each substantially correct.

At different elevations of the water plane the areas of reservoir surface and capacities of reservoir space are as follows:

Elevations of water plane.		Corresponding areas of reservoir surface.	Capacities of reservoir: Totals above ground surface.	
Above base of dam.	Above outlet.			
Feet.	*Feet.*	*Acres.*	*Cubic feet.*	*Mill. galls.*
5	....	0.75	65,000	.48
10	0	4.95	631,000	4.72
15	5	10.23	2,271,000	16.99
20	10	34.93	6,921,900	51.78
25	15	141.36	17,898,450	133.87
30	20	294.54	67,850,660	507.52
35	25	427.79	145,808,450	1,090.65
40	30	1,060.01	312,153,521	2,334.91
45	35	1,425.02	581,855,607	4,352.28
50	40	1,691.41	920,824,487	6,887.77
53	43	1,858.99	1,152,729,883	8,622.41
55	45	1,960.49	1,307,277,775	9,778.44
57	47	2,069.26	1,482,801,898	11,091.36
60	50	2,251.50	1,763,166,320	13,188.38
65	55	2,532.00	2,283,791,020	17,082.76
70	60	2,812.00	2,834,253,750	21,199.22
80	70	3,300.00	4,161,190,000	31,125.70

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PROJECTS OF THE NORTH POUDRE LAND AND CANAL COMPANY.

The superintendent, Mr. J. C. Ulrich, states: Our principal work is developing some reservoirs on the canal line up on the plains, located 40 miles north of Fort Collins. There are natural depressions on the plains, and we make a cut from those natural depressions; then a pipe is put in the cut and "fills" are built which will retain the water that is afterward drawn off to irrigate the land. The object is to store the excess and use the same when the need requires. They are to be filled when the rivers are high, and the amount of water used by other ditches is small. At present we have four reservoirs constructed, with an aggregate capacity of 175,000,000 cubic feet. When the system is completed, we expect to serve probably seven or eight times as much as we can at present irrigate. The North Poudre Land and Canal Company's Canal is about 25 miles in length. It is 16 feet wide on the bottom, with an average depth of about 4 feet. It has a grade of about 2½ feet to the mile on the first 7 miles and 4 feet on the rest of it, on the lower division. We estimate that it will carry about 300 cubic feet per second. The first 7 miles are in the mountains or foot-hills, and after getting out on the plains we strike the land which we expect to irrigate. One has an area of about 100 acres and a depth of 14 feet. The next reservoir brings two "fills" together, containing each about 35 acres, about 9 feet deep. The third contains 160 acres 26 feet deep. That is as far as we have completed the system at present. Then, below the last one I have mentioned (south of it), is a chain of proposed reservoirs, aggregating something like 2,500 acres. The total cost of this ditch was about $175,000. It will take about $50,000 to complete the reservoirs. By an expenditure of $50,000 we increase seven or eight fold the capacity of a ditch that cost $175,000.

Dam at head of North Poudre Canal.—This dam is 30 feet 6 inches high in the center, and 150 feet broad at the top, and is formed in two parts. The face, which gives the necessary stability against floods, consists of crib-work and stones; the back, which renders the dam water-tight, is a vertical panel, or diaphragm of timber, backed with earth, small stones, gravel and mud, thrown in without puddling. The crib-work is formed of round logs 10 inches, at least, in diameter, joined at ends, as in ordinary log huts, with dove-tail or tongue joints. The cribs are 10 feet long on the face, and are fastened together with 18-inch tree-nails, 2 inches in diameter. The cribs are radiated to form, when laid close together across the stream, curved ties of 200 feet, 216 feet, and 232 feet radius on the face. There are three of these tiers 6 feet asunder. The interior of these cribs, and the spaces between the stones, and the interior surfaces, are faced with large selected blocks of stone, carefully laid so as to overlap each other like slates or tiles of a house, and without mortar. The arrises are protected by 12-inch square balks, securely bolted to the cribs. The timber diaphragm is carried 4 feet higher than the cribs and stone-work of the tallest tier, to form a slash-board, which can be removed in sections in case it is found liable to be damaged by ice. The center portion of the dam for a length of 60 feet is carried 2 feet higher than the sides, to throw the bulk of the stream onto natural benches of solid quartz rocks on the sides, and thereby to protect the greater part of face, and especially the toe in the center of the stream, from the abrading power of the water.

The total cost of this dam was $7,250. The dam was founded on stone and débris, the depth of which had not been sounded, but it was hoped that the clay thrown in the back of the dam, combined with the silting

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up of the river, would have the effect of stopping the flow of the wat and the result justified the expectation. This dam is not intended storage purposes, but is simply a weir for raising the water high enou to enter the flumes and tunnels. The canal regulators are ordina sluices, inserted in the flumes about 100 feet below the dam.

The objections that are urged against timbers being used are met the fact that the massive stone, or masonry in cement, which wo have been requisite to secure the mass of material used, would have be too costly. The cost, $7,250, was very low for a weir 144 feet long, l the foundations were not necessarily extensive, and the source of supp of stone and timber was at hand.

Montezuma Valley, in southwest Colorado, is the seat of a great i gation enterprise. It is described as follows: The valley is about miles long, running from northeast to southwest, and is nearly 10 mi wide. The water is to be taken out of the Dolores River at the nor east end of the valley. The State has located about 26,000 acres land in the valley, and probably about 10,000 or 15,000 acres have be located by actual settlers, leaving between 50,000 and 100,000 acres unclaimed. The locations are principally at the upper end of the vall near the tunnel.

The Grand River canal, in western Colorado, has a width at the b tom of 35 feet, on the top of 50 feet, and a depth of 5 feet for the fi 10 miles. The size then diminishes until for the last 2½ miles the wi is 16 feet on the bottom, and the depth 3 feet. The grade is .035 hundred, or a little over 22 inches to the mile. The banks are give slope of 1½ to 1, are 3 feet wide on top and 2 feet above the water s face. There are several drops, one of 6 feet, one of 13 feet, and one 35 feet, while down the valley about 14 miles there is a final fall about 14 feet. Just above the second fall a lateral canal has been c ried out on the upper level, a distance of 17 miles down the valley, c rying 3 feet of water. The location of the head is so favorable tha full head of water can be taken out of the river at its lowest stage supply, so that water in this canal, in consequence of the volume r ning in winter season, can be in operation the year around, a fact ve important in Grand Valley, where it is assumed that late irrigation w be advisable and early irrigation a necessity for the germination seed. The flumes, head-gate and waste-weirs have been built in t most substantial manner.

KANSAS AND THE UPPER ARKANSAS VALLEY "UNDERFLOW."

From records kept at Dodge City during the last eighteen years, a from information gathered from other reliable sources, we believe it safe to depend on an abundant supply of water for irrigation in t Arkansas Valley in at least seven years out of ten. If these same matic conditions are to be looked for in the future, would it not be w to make some provision for these three years of drought? Manifes so, if the conditions are present which will render such a provision p sible. Various methods of utilizing the underflow of the Arkan River to supply the irrigating ditches with water, which the river fai to furnish during seasons of deficiency in precipitation, have been d cussed. That the supply of water is inexhaustible has been frequen demonstrated by pumping water from wells located in the valley. T two most noted experiments were made last year at the wells wh supply the water-works at Dodge City and at Garden City. Th wells are 22 feet and 19 feet in diameter, respectively, and about 20 f

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deep; the water rises to within 4 feet of the surface of the ground. Over 1,000,000 gallons have been pumped out of the Dodge City well in a single day without lowering the water to any appreciable extent. At the Garden City well the water-works pump, with a capacity of 600 gallons per minute, and a Huffer irrigation pump, with a capacity of 500 gallons per minute, were both worked to their utmost limit for a period of four hours without lowering the water in the well. Numerous other experiments of a similar nature have been made.

The South Dodge Canal Company was organized last year with a capital of $250,000. The officers of the company are E. E. Soule, president, G. G. Gilbert, vice-president, and J. W. Gilbert, secretary. This company has secured the right of way for 35 miles of irrigating ditch on the south side of the Arkansas River. Fifteen miles of the ditch have already been completed. It will be known as the South Dodge Canal. Nearly 100,000 acres of valuable lands may be irrigated by this canal. The ditch extends from Howell Station, 8 miles west of Dodge City, to Ford City, a distance of about 35 miles. The original survey provides for taking water from the Arkansas River at the south bank, opposite Howell Station. It is at the head of the South Dodge Canal that the experiments are being conducted for securing a flow of water in an open channel from a reservoir to which the water is supplied by the underflow of the Arkansas Valley.

The reservoir, or head of the canal, is located about 60 rods from the river bank. At a point 1⅜ mile from the head the ditch was built exactly at grade—*i. e.*, the bottom of the ditch is on a level with the surface of the ground, the bank of the canal being levees about 8 feet high. Commencing at the grade point the excavation of the upper end of the ditch was begun, due allowance being made for the proper fall. At a distance of about half a mile the water-bearing stratum of sand was reached, the bottom of the ditch at that point being about 4 feet below grade. After reaching this sand the soil was then stripped off to the head of the ditch, the work all being done by teams and scrapers. The ditch, at a point 2,000 feet from its head, is 30 feet wide at the surface of the ground. This increases to 60 feet at the head of the ditch. For this entire distance of 2,000 feet both sides of the ditch are protected by sheet-piling.

The company did not expect to secure a flow of water at this stage of the excavation, but contrary to their expectations the water began to accumulate and run in a strong current down the ditch and in such a quantity that it was necessary to put in a head-gate and cut-off at the grade point 1⅜ miles from the head of the reservoir. The flow extended over 8 miles, and as far as the ditch had been completed at that time. Since the head-gate and cut-off have been put in no water is allowed to pass below it in the ditch, but is turned off at the side of the ditch and runs in an open channel to the river, which at that point is about 100 yards from the ditch. The writer measured the flow of water at the point where it falls over the river bank, and found the stream to be 4½ feet wide and 13 inches deep. It will be remembered that this result has been obtained without any reservoir yet being constructed.

The head of the ditch, as before described, will constitute the reservoir, and will be 60 feet wide at the upper end, 30 feet at the lower, and 2,000 feet in length. The sand will be excavated by a dredging-machine, which was placed in position on Saturday, February 1.

Owing to the extreme cold weather which has prevailed during a greater part of that month the work of excavating the reservoir progressed very slowly. Over 200 feet was completed by the 7th instant.

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The excavation was begun at the upper end. Two dredging-machines are in operation, and if the weather is favorable the work will be completed by the 25th of this month. The flow of water has increased largely, and is now fully 2,000 gallons per minute. If the water continues to rise to the same height at which it has been found impossible to reduce it in small wells by pumping, the profile and survey of the ditch provides for a stream of water 5 feet in depth at the grade point before mentioned. The managers feel confident that this supply can be secured.

As an experiment, the work has been a complete success; the water will, and does, flow in an open channel from the underflow of the Arkansas Valley; the channel does not fill with sand, and manifests no disposition to do so.

The Gilbert Bros. have had the general management of the constructing of these ditches. On the 7th the Eureka Ditch, 96 miles in length, was full of water, besides over fifty storage reservoirs of from 5 to 40 acres in area. The Dodge City Canal and the Eureka Ditch will both be furnished with reservoirs for supplying water from the underflow of the Arkansas River this season.*

PROPOSED UTILIZATION OF THE SIERRA LAKES.

In western Nevada the use as reservoirs of the Sierra Lakes, etc., has been projected on a massive scale. Without indorsement the outlined plans are presented. In surveying Donner Lake and the valley an elevation of 20 feet above the present lake is obtained. This will make a reservoir of over 5 square miles, with an average depth of 40 feet, holding an estimated volume of 5,575,680,000 cubic feet of water in a natural land-locked basin. The elevation is 5,885 feet above sea level.

The outlet will be by a high-line canal along the benches on the north side of Truckee to the plateaus north and northeast of the place and to the east of Boca and Verdi, crossing Prosser Creek and the Little Truckee River. There can be selected reservoirs at that point in which water enough can be stored to fill Dog Valley. This will ultimately become available for the valleys and plateaus north and east of Reno. A dam across the Truckee River about 1 mile above the Central Pacific depot is also located to make a reservoir 3 miles in length along the Truckee Valley. The outlet from this reservoir will be on the south side of the Truckee River, along the benches and high foot-hills south of Truckee City, around the Marquis plateau and meadows into Marquis Creek, which flows into the Truckee River near Boca, about 10 miles below Truckee. This canal through Truckee and along the hill-sides may also afford an excellent water-power for mills, etc., for a mile or more before being used on the plateaus, and again entering the Truckee River offer an ample supply for Truckee meadows, or it can be carried by a higher-line canal to and around the Washoe Basin here in western Nevada.

This dam, with the reservoir it will create in the Truckee, taken in connection with Lake Donner, will store, the two together, nearly or quite 6,000,000,000 cubic feet; quite sufficient for the supply of all lands now under ditch or available therefor; as well as the reclamation of at least 1,000,000 acres more. Lake Tahoe, by a dam at its outlet near Tahoe City, can readily be raised 8 feet. It has a drainage basin tributary to its supply of at least 5,000 square miles. Lake Tahoe

* Date of March, 1890.

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should be held in reserve—the great storage reservoir which will meet extraordinary needs. Over one-third of its area is within the boundary-lines of Nevada. A tunnel has been proposed to lead into the Carson Valley, by which the water thus stored can be drawn from its depths, at least 1,000 feet below its surface. Three lines across the Sierras between Lake Tahoe and Carson Valley have been run, the best being near the southeast portion of lake Tahoe and the head of Carson Valley, all in the State of Nevada, locating a tunnel 10 by 10 feet, with a crown of 2 feet in center. The open cut from Lake Tahoe to the entrance of the tunnel will be 4,200 feet; the length of tunnel 17,331 feet, or 3.45 miles, the cut and tunnel having a grade of 2 feet per mile. The exit of the tunnel on the Carson Valley or east side is to be 1,500 feet above the valley.

The output of this tunnel can be carried both north and south along the foot-hills and carried to any portion of the upper Carson Valley, and thence into the Carson River. In addition to the great benefit to be derived from the placing of this water upon the Carson Valley lands, a magnificent water power can be secured and utilized along the east side of these mountains, and dynamos charged so that this power can be transmitted to Carson and Empire where the Virginia City mills are located, and the water used over again in Douglas, Ormsby, Washoe, Lyon, and Churchill Counties, all of them in Nevada. It is a perfectly feasible and not an expensive project either. A dam will have to be located also at the outlet of Lake Tahoe on the west side at Tahoe City to raise the lake 8 feet. The inlet to the canal and tunnel is located so as to receive 20 feet depth of water at high-water mark. This will give 200 square miles of surface water 20 feet deep, equal to 111,513,600,000 cubic feet. The lake will never be more than 12 feet lower than the present height. This grand reserve reservoir can be turned either into the Carson or Truckee basins. The elevation is 6,200 feet.

Hope Valley, at the head of the West Fork of the Carson, is found to be an admirable location for a large reservoir. By making a dam 150 feet high a surface area of not less than 5 square miles with an average depth of 50 feet can be secured. This dam we located at the foot of the Carson Valley and at the head of Hope Cañon, which has a granite ledge on both sides. For the first 100 feet in height it has a narrow gorge of 200 feet at bottom and 800 feet in width at top, with rock benches about 500 feet on either side above the first 100 feet. This is a land-locked valley about 5 miles in length, an average of 1 mile in width, 7,658 feet above the sea, and will hold 6,969,600,000 cubic feet of water, with average depth of 50 feet. This reservoir will require two outlets to be cut in rock on both sides, and the water can be then turned into the river below. This is the West Fork of the Carson River. It would conduct the water 6 miles down Hope Cañon to a diverting dam to be located about 1 mile above the mouth of the cañon, where a canal on the left or north side of the river would conduct the amount of water required along the foot-hills at the base of the mountain and north of the cañon at any desired height as far north as Sheridan or Genoa, and distribute it then down the foot-hills and into the valley until it reaches the West Fork of the Carson River. From this same diverting dam, 1 mile above the mouth of Hope Cañon, on its right bank, another canal can be constructed along the right bank of the West Fork of the Carson River, with a sufficient grade to conduct any portion of this water from the Hope Valley Reservoir across Diamond Valley 2 miles in length; this is located at the foot of Hope Cañon,

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with an elevation of 5,481 feet, then through Dutch Valley, with an elevation of 5,277 feet, and this also about 2 miles in length; thence into Long Valley, which has an elevation of 5,078 feet above the sea and about 200 feet above the head of Carson Valley. There are already three ditches running from Hope Cañon and conveying water through Diamond Valley to Dutch Valley, whose natural drainage is into Long Valley. One of these ditches can be enlarged into a canal, and the flood and natural water from the West Fork of the Carson can be secured to Long Valley, which is a good, natural, safe location for a grand receiving reservoir; all outside of any river channel.

With a dam 100 feet in height at a narrow neck of Long Valley about 1 mile above the head of Carson Valley nearly or quite 4 square miles of surface water with an average depth of 50 feet can be obtained. This will give 5,625,680,000 cubic feet of water for distribution by a canal on the east side of the Carson Valley, which will supply not only the Empire Mills, but also all that the 100,000 acres of land on the east side of the Carson River (that now has no water for irrigation) may require. A canal from the left side of this dam out on the benches at the head of the Carson Valley may be supplied from this same source. The east or main fork of the Carson River runs almost parallel with Long Valley for the 3 miles east before debouching into the Carson Valley proper. At Horse Shoe Bend, a point about 2 miles from its mouth, there is a narrow saddle ridge, where with an overflow dam across the East Fork or main river can be turned through a tunnel or cut of about 1,000 feet in length. This will turn the water through a 10 by 10 feet tunnel or cut 10 feet wide at bottom and with its slopes of 1 to 1.

Pleasant Valley, on the Middle Fork of the Carson, in Alpine County, Cal., 12 miles south of Hope Valley, which is about 3 miles in length and 1 mile in width, can be made from 40 to 50 feet in depth as a reservoir, with a water-shed of 50 square miles, and it has good rocky flanks at the lower end of the valley. This location is 3 miles above Markleville, Cal., and in it can be stored 3,345,408,000 cubic feet of water. Below this reservoir and above Markleville are the waters from Burnside Lake, Hot Springs Creek, Charity Valley, and other mountain creeks. At Markleville, 18 miles above Long Valley, the East and Middle Forks of the Carson unite, thus making the East Fork the main Carson River, so that by the diversion of the East Fork at Horse Shoe Bend, Long Valley can receive the water of all the branches of the Carson to its full or maximum capacity. Twelve miles above the junction of the Main and East Forks of the Carson River Silver Creek joins the East Fork. Five miles farther southeast Wolf Creek empties into the East Fork. One mile above the mouth of Wolf Creek is a meadow, where from 1 to 2 square miles surface of water can be stored with a depth of 40 feet. Two miles above Wolf Creek, at Silver King Valley, on the East Fork of the Carson, another reservoir can be located with a water surface of 2 square miles. Now, all the above-named reservoir sites in Alpine County are above 6,000 feet elevation. Other sites have been examined, but found impracticable. The water-shed for the Carson River and its branches is fully 1,000 square miles.

At Wadsworth, Nev., 34 miles below Reno, the Truckee River turns north and sinks into Pyramid Lake, 15 miles from Wadsworth. At a point on the Truckee 5 miles west of Wadsworth an admirable location for a diverting dam is found, which can be built of stone in rocky bluffs 116 feet higher than the water surface at the Wadsworth bridge. A dam and reservoir has also been located there, and our men are running levels for canals on either side of said river to conduct the water out

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on the plateaus and benches north, east, northeast, and southeast from Wadsworth. The bridge, which is now 30 feet high, can be filled up, and a 10 by 10 feet outlet and canal put in on each end of the bridge to guard against any possible flood or overflow or accident. This water can be extended along the benches if required.

By storage of the flood waters at the head of the Carson and Truckee Basins and other water-sheds along the eastern slopes of the Sierras at least 500,000 acres of fertile lands in California and not less than 2,500,000 acres of good arable lands in western Nevada can be reclaimed and cultivated; all this in addition to the area now under cultivation. It will be seen that the aggregate amount of water in the reservoirs already selected is estimated at 133,229,968,000 cubic feet of water, and from the best information obtainable the reservoir can be filled annually from natural water-sheds. The demand for water in this State is at the rate of 1 cubic inch per acre, and is much in excess of that generally required in the State of California. The estimated amount for the reservoirs now located will furnish an acre-foot for 3,000,000 acres of land. I am convinced that we shall be able to find reservoir sites that will hold an amount sufficient for another 2,000,000 acres of land; that is, having an acre-foot of water for each acre. This will make 5,000,000 acres that can be reclaimed in this division by the storage of water sufficient therefor. The waters of the Truckee and Carson and auxiliary springs have been carefully gauged daily, giving the velocity and quantity and discharge in cubic feet per second. A sample of the gauging of the Truckee River at Essex above the ditches and canals is as follows:

	Name.	Mean velocity.	Discharge.
			Cubic feet.
May 20	Truckee at Essex	2,630	2,336.67
22	....do	2,767	2,511.94
28	....do	1,983	1,716.25
June 20	....do	358,549	350.49
May 22	Dog Creek	.....	6.89
24	Prosser Creek	.....	312.52
June 21	....do	.....	64.33

IRRIGATION ON THE RIO PECOS, NEW MEXICO.

The Rio Pecos rises in the northern part of New Mexico, northeast Santa Fé.

It flows in a southeasterly direction to the neighborhood of Fort Sumner, and then a little east of south across the Territorial line into Texas, finally forming a junction with the Rio Grande.

It is a mountain stream, subject to alternate flood and drought, until it reaches the neighborhood of Roswell, N. Mex.; thence for 100 miles, in a due south line, it runs a tortuous course of probably 250 miles, receiving at intervals large quantities of spring water.

These springs generally flow into it along its bed, following the general limestone strata of the country.

They represent the drainage from the eastern slopes of the Capitan, Sierra Blanca, Sacramento, and the Guadalupe Mountains, and the waters of the upper river which disappear below Fort Sumner.

Careful measurements show that the permanent supply is sufficient to fill both of the canals now in course of construction, and calculated to carry 1,600 cubic feet per second, or 80,000 miner's inches.

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The drainage area, or catchment basin of the Rio Pecos, within the Territory of New Mexico, and available for irrigation purposes, is approximately 20,000 square miles, at varying altitudes from 3,000 to 11,000 feet, and extending across four degress of latitude from the thirty-second to the thirty-sixth parallel.

The lands of the valley between Roswell and the Territorial line subject to irrigation are of the choicest limestone soil, and the total area between the foot-hills on the west and the river is nearly or quite 1,000,000 acres. Of this fully 400,000 acres are below the level at which it is practicable to deliver water from the Pecos.

The 40 miles of the Northern canal, now under contract, will cover about 75,000 acres of bottom and mesa land, and more than that area can be covered by extending the canal farther south.

The Southern canal is much the larger one, and will irrigate more than 100,000 acres on the west side of the river, north of the Texas line, while there is practically unlimited area that can be made available, by extending south of that line. Several bodies of choice land can also be covered on the east side of the river if desirable.

The Northern canal is being constructed 30 feet wide on the bottom, with sides sloping 1½ to 1 foot, and to carry water 5 feet deep, taking its supply from the Hondo, the principal tributary of the Rio Pecos, below the junction of the North Spring and Barenda Rivers, deriving its chief supply from permanent springs of great volume. Three miles from its head it crosses and receives the waters of the South Spring River, and is deepened to 6 feet to accommodate the increased supply at that point. These streams are all fed by permanent springs.

The Southern canal was constructed a distance of 11 miles, with the capacity to irrigate 30,000 acres. It is being enlarged to 45 feet wide at bottom, 63 feet at the top, and 6 feet deep, and by careful computation is intended to utilize all the available water of the river during the entire irrigating season. Its length within New Mexico will be 55 miles.

It is taken from the east side of the Rio Pecos a few miles below Seven Rivers. Although the waters of the Pecos are sometimes enlarged by floods, at the point where this canal is taken from the river, a dam 3 feet high, built at trifling expense, suffices to turn the water to fill the canal. It is controlled by head-gates, and the fall of the river is so great at that point that the rise does not exceed 6 feet—indeed, it never gets out of its banks. The river is a succession of rapids, and the fall within 6 miles amounts to as much as 50 feet. Very much of the water can be utilized at the crossings of arroyos for water-power, and then be discharged so as to cover large areas of agricultural land, without any loss of water. The canals are secure from floods. On the Hondo the reservoir at the dam backs fully half a mile up-stream, making dead water, and giving perfect control.

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BLANKS AND FORMS USED IN DITCH MANAGEMENT.

[Northern Colorado Irrigation Company, Denver, Colo.]

RULES FOR EMPLOYÉS ON THE PLATTE CANAL.

D. W. Payne, division superintendent.

Division No. 1.

This division of the canal commences at ——— ——— and ends at ——— ———.

You are specially under the orders and directions of the engineer, and you are to carry out faithfully and promptly all his instructions. You will frequently and closely examine every part of the canal in your division, and enter in your weekly report any remarks that you may think necessary regarding the general condition of the works. Should there be a necessity for immediate attention to any part of the canal, report immediately on the telephone to the office, or if before 9 o'clock a. m. or after 4 o'clock p. m. ring the number on the telephone for the engineer. Failing to get an answer from the engineer ring the manager's number.

Should a serious leak, or break, or overflow occur, you will immediately make every effort to stop it, and to accomplish this you may hire such assistance as may be necessary and close at hand. Open the nearest waste gates above the leak, or break, or overflow, and if necessary to have all the water shut out of the canal, telephone to Denver to any of the three calls there. Should the accident be one that you can overcome without great difficulty, do not lose time by leaving it and trying to telephone, but get such assistance as may be nearest. If necessary, send or go to the nearest telephone and give notice to the engineer.

All employés on the canal are required to promptly render assistance to each other whenever there is any necessity for so doing. Each division superintendent shall keep a daily record of the depth of water on the guage or guages in his division, and will report the same to the engineer by telephone daily.

Each division superintendent shall provide himself with a suitable horse and cart, if such conveyance be required, and shall at all times carry with him a shovel, hammer, nails, screw-driver, wrench, measuring rule, and telephone tools, all of which, except the horse and cart, and feed for horse, will be provided by the company. In addition to these tools, there should be on each division oakum and sacks, and division superintendents will promptly notify the engineer when additional supplies are needed.

Expenses.—Except in cases of emergency, such as leaks, breaks, or overflows, or danger of any of these, no materials or tools shall be purchased or obtained on the credit of the company, except by the engineer or on his order, and no labor shall be employed except in emergencies as above stated, without first having the authority of the engineer. In all cases where laborers or mechanics are employed, the person in charge of the division where the work is being done shall keep a full and complete record of the time each person is employed and the wages to be paid, unless the engineer shall place some other person in charge of the work.

All payments for wages or hire of any kind and for material shall be made at the office of the company in Denver, and then only upon properly stated and certified accounts first approved by the president or manager.

Care of property.—All property of the company must be carefully watched and protected on each division by the division superintendent, and he shall be responsible for locks, keys, gate-pins, tools, bolts, bars, or other effects. He shall report promptly to the engineer or manager all cases where the property of the company has in any way been tampered with or damaged, such as the cutting or breaking of gates or weirs, or interference in any way with the banks of the canal or flumes. He shall also report all cases where any damage has resulted to the property of others by reason of overflow or breaks, or in any other way.

Distribution of water.—Such water as may from time to time be in the canal shall be divided pro rata to all persons entitled thereto by reason of their ownership of water rights, and each person in charge of a division shall in the most impartial and careful manner turn water out of their respective gates in strict accordance with the directions given from time to time by the engineer or from the manager's office, and under no circumstances is any person to be allowed to open a gate or in any way to obtain more water than the quantity stated in the directions. The gate on every outlet must at all times be kept locked and the division superintendent must at all

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times carry the keys with him. He shall carefully inspect all gates, weirs, and outlets every day to see if all be in good order; also to discover if the gates are being tampered with, and he shall measure and record every day the depth of water flowing over each weir, and enter the same in the reports prepared for such purpose. Look sharply for persons having duplicate keys.

All outlets are to be kept free and clear of drift-wood and all other floating matter, and the gates should be frequently examined to see if there be a free flow under them; also that no wedges have been driven under them by persons trying to get more water.

Do not accept the statement of any person about water; all instructions pertaining thereto will be given on the telephone, or in writing, from the proper authority.

Report promptly the name of any person who offers any bribe or any inducement to get more water than is then being allowed under the directions given you.

Whenever there is a rise in the water in the canal, not caused by floods from the prairie, the quantity running over the weirs in the lateral ditches should not be allowed to increase by reason of the greater pressure on the outlets. The gates in the outlets should be partly closed down so as to give just the same depth of water over the weirs as was running before the rise, unless orders contrary to this have been given from proper authority. In almost every instance when more waste is taken into the canal from the river, the extra quantity is intended for the divisions at the end of the canal. When a sudden great rise occurs in the canal by reason of flood water from the prairies, caused by a storm, make haste to the water gates and open them, also let out at all the outlets in the canal as much water as the lateral ditches will fairly carry without overflowing or doing any damage.

Whenever there are indications of a storm and a flood, the waste-gates should be opened before the flood comes. Good judgment and prompt action in emergencies of this kind will determine the efficiency and earnestness of the employé in the duties assigned to him.

Whenever you see that water is being allowed to run to waste by any irrigator, reduce the quantity running over the weir to the extent of such waste. If you see that a lateral ditch is broken, and the water is running to waste, shut off the water and notify the superintendent of the lateral or some person who is using water from it. Make a record of your action in every case of the two above kinds, and state the particulars in your weekly report.

NOTE.—There must not be any absence from duty unless permission first be obtained from the engineer or manager.

There must not be any scolding with, or rough language applied to, farmers or users of water. You can perform your duty better without this. If any one assaults you without just provocation the company will assist you in a prosecution.

Any case of intoxication or any neglect of duty, or apparent indolence or indifference on the part of an employé will be met with prompt dismissal.

All reports must be carefully and accurately made, so that, if necessary, they can be sworn to.

S. J. GILMORE, *Manager.*
GEORGE G. ANDERSON, *Engineer.*

THE NORTHERN COLORADO IRRIGATION COMPANY.

Record of depths of water at the weir, at the city limits of Denver, for the week ending Saturday, ———, 188—, *at 6 o'clock p. m.*

Day.	7 a. m., depth in inches.	6 p. m., depth in inches.	Average depth per day.	Discharge in cubic feet.	Total quantity in gallons.	
Sunday						
Monday						
Tuesday						
Wednesday						
Thursday						
Friday						
Saturday						

I certify that the depths of water entered above in the first two columns are true and correct.

———— ————.

I certify that the depths given above in the first two columns and the average depths given in the third column show a total delivery of water for the week ending as above, of —— cubic feet, or the equivalent of —— gallons.

———— ————,

————.

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Record of depth of water on weirs in third division for the week ending Saturday, September 16, 1888.

Outlet number.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
47	No water in the ditch.	Do.	Do.	Do.	Do.	Do.	Do.
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
75							
76							
77							
78							

I certify that the depths of water entered above are true and correct.

THOS. EVANS,
Division Superintendent.

Record of depths of water in flumes, etc., for the week ending Saturday, ——— 18—.

Location.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
Dam							
Cañon Flume							
Plum Creek.....							
Bennett Gulch ...							
Little Dry.....							
Cherry Creek							
Section 1 Check..							
Dryer's Check ...							

I certify that the depths of water entered above are as telephoned to me daily by the respective division men.

———— ————,

————— ————.

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Report of services performed during week ending Saturday evening, ———, 18—, by ———

Sunday,

Monday,

Tuesday,

Wednesday,

Thursday,

Friday,

Saturday,

The Northern Colorado Irrigation Company. Report of services performed by ——— ———, for week ending Saturday evening, ———, 18—.

[Fill in every evening, and not wait to end of week, when you may have forgotten particulars.]

NOTE.—This report may be made in pencil. It need not include all the little details of work, but should be sufficiently full to clearly indicate what was done each day. It should be sent by mail, or otherwise, at the first opportunity, to

S. J. GILMORE,
Manager, Denver, Colo.

BLANK WATER CONTRACT FORMS AS USED IN COLORADO.

No. I.

Know all men by these presents, that the ——— ——— Canal Company, a corporation existing under the laws of the State of Colorado, of the first part, and ——— ———, of the county of ——— and State of Colorado, of the second part, for and in consideration of the sum of $—— to be paid as hereinafter specified, and in consideration of the mutual covenants and agreements in this contract contained, to be performed and kept, the said company hereby agrees to carry and convey for the use of the second part—, ——— statutory inches of water in and through the canal of said company, subject to the following terms and conditions, to which the said part— of the second part, —— heirs and assigns, hereby expressly agree:

I. The said company agrees to carry and convey the said water in its said canal for the use and benefit of the said second part—, —— heirs or assigns, continuously during the irrigating season, except as hereinafter provided, and at no other time, unless with the consent of said company thereto in writing.

II. Said water shall be used only for irrigating and domestic purposes on the following described tract of land, and none other, to wit: ——— ———, and under no circumstances shall said water, or any portion thereof, be used for mining, milling, or mechanical power, or for any other purpose not directly connected or incident to the purposes herein specified.

III. Said company expressly reserves to itself the right to distribute the water from its said canal in accordance with such rights and priorities as are or may hereafter be established or decreed; and this contract is received by the part— of the second part subject to such priorities.

IV. The said second part—, —— heirs or assigns, shall not permit said water, nor any portion thereof carried as aforesaid, to run to waste, but as soon as a sufficient quantity shall have been used for the purposes herein allowed and contracted for, the said second part—,——heirs or assigns, shall shut off said water and keep the same shut and turned off until the same shall be again needed for the purposes aforesaid. But in no case shall the amount of water taken or received by said second part—, —— heirs or assigns, exceed the quantity first herein referred to, and said company hereby reserves the right at any time to shut off the water herein mentioned whenever it shall find that the said part— of the second part — — wasting it or not using it in accordance with the agreements herein contained on the land above mentioned.

V. The said company shall deliver said water at such point or points along the line of said canal or ditch, or from any of its reservoirs, laterals, either or all, as it may determine to be the most practicable, and the manner of withdrawing and regulating the supply of said water from said company's ditch and reservoirs shall be prescribed by said company, and shall at all times be under its control, as determined and directed by the said company. The head-gates, flumes, weirs, or other arrangements or devices, and all measuring boxes and devices through which the water hereby contracted to be carried shall be drawn and measured from said company's ditch or res-

ervoirs, shall be made and placed in position by the said company but at the cost of said second part—, who shall also be liable for the expense of keeping the same in good repair and condition; and the said company may collect and enforce the payment of all sums expended for said purposes in the same manner as prescribed for collecting and enforcing assessments.

VI. The said first party agrees to keep and maintain said main canal or ditch and any and all of its reservoirs and laterals in good order and condition, and in case of accident to the same, to repair the injury thereby occasioned, as soon as practicable and expedient; and the company shall have a right to assess the said second part— for its expenses of maintaining, repairing, and operating said canal, and any and all reservoirs and laterals connected therewith, including taxes and legal assessments on said canal, a sum not exceeding ——— per statutory inch hereby contracted to be carried, per annum; and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights, pro rata, such sums as may be necessary to repair the injuries so occasioned, ——— the amount of all assessments herein provided for shall be determined and levied by said company by resolution of its board of directors, and the company also reserves to itself the right by like resolution to establish and enforce such rules and regulations, and to provide and declare such penalties as it may deem necessary and expedient for the purpose of enforcing and collecting said assessments or any part thereof. Said assessments shall be due and payable at such time as may be fixed by the board of directors of the first party, and the second part— hereby agree— to duly pay the same, and further agree— that the failure to pay the same or any part thereof within sixty days after notice of the levy of any assessment (which notice may be either personal or by registered letter addressed to the second part— at ———, Colorado) shall, at the option of the board of directors of the first party, constitute a forfeiture of all the rights of second part— as provided in paragraph XIII of this agreement.

VII. The said first party shall have, and the said second part— hereby grant — to the said first party, a right of way across said above described land of the width of ——— feet for the main canal as now located and a right of way for the laterals of said first party as now located, of the width of —— feet, and also the right of roadway on the banks of the canal and main laterals; and in case a fence is constructed by said second part — across said roadway —— shall construct and maintain a gateway across said bank, when said first party requests, in which case said first party shall close said gate when opened by it.

VIII. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the first party shall be unable to carry and distribute a volume of water equal to the estimated capacity of its canal, either from casual, unforeseen, or unavoidable accidents, or from any cause beyond the control of said first party, or if the volume of water prove insufficient from drought or from any other cause beyond the control of said company, the company shall not be liable in any way for the shortness or deficiency of supply so occasioned, or any loss or damage resulting therefrom by reason of any of said causes. If, however, by reason of such causes, or any of them, the supply of water be insufficient to furnish an amount equal to all the water rights then outstanding, the said company shall have the power and the right to distribute such water as may flow through said canal to the holders of such water rights pro rata, or may alternate the same; and for the purpose of so doing may establish and enforce such rules as it may deem necessary or expedient. And the second part — for —— and —— heirs and assigns, agree— in consideration aforesaid, to waive, and hereby do— waive, any claim for loss or damage by reason of any leakage, overflow, or breaking of said company's canals, or any of its reservoirs, lakes, or laterals, either upon the land aforesaid or any other tract belonging to the part— of the second part, provided the same is not caused by the negligence of said company.

IX. The said company agrees that when it shall have sold and have outstanding and in force a number of water rights equal to the estimated capacity of the company's canal, or sooner, at its option, it will then transfer to the holder of each water right, who shall have complied with the terms and conditions of this contract, without further consideration, such a proportion of the number of shares of the capital stock of the said ——— company as the number of water rights held by —— bears to the whole number of water rights held or outstanding in the canal of the company, or as near thereto as may be possible without making fractions of shares, and which said shares the second part— agree— to accept: *Provided, however*, That such transfer is to be made only on the express condition that the first party shall thereupon and thereafter be absolutely released from any and all obligations or liabilities arising out of the ownership, operation, management, or control of said canal, or out of any contract (including this) pertaining to the distribution of water therefrom, which said obligations shall be assumed by said holders of water rights, who shall pay all expenses incident to such transfer; which said condition the said second part—, in consideration thereof and of these presents, for —— and —— heirs and assigns do— hereby accept. Such transfer shall only be made when the canal is in good order and unencumbered.

X. It is further agreed that the irrigating season shall commence April 15 and

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continue to November 1st of each and every year, and that thereafter water shall be conveyed for domestic purposes whenever reasonably practicable; subject to the right of said first party to shut off the water in order to repair or enlarge or extend said canal.

XI. The payment of the consideration heretofore specified herein shall be as follows: ——— dollars upon the ensealing and delivery of this contract, payment of which is hereby acknowledged, and the balance in ——— payments at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment....	.....	.....	.....	.....	.....	.....	.....
Second deferred payment..	.....	.....	.....	.....	.....	.....	.....
Third deferred payment....	.....	.....	.....	.....	.....	.....	.....
Fourth deferred payment..	.....	.....	.....	.....	.....	.....	.....
Fifth deferred payment....	.....	.....	.....	.....	.....	.....	.....
Sixth deferred payment....	.....	.....	.....	.....	.....	.....	.....
Seventh deferred payment.	.....	.....	.....	.....	.....	.....	.....
Eighth deferred payment..	.....	.....	.....	.....	.....	.....	.....

Said deferred payments shall bear interest at the rate of —— per cent. per annum, payable annually, and shall bear interest after maturity at the rate of —— per cent. per annum, and the second part— in consideration of the premises hereby agree— that —— will make punctual payment of the above sums, and each of the same, together with the interest thereon as the same respectively become due; and that —— will regularly and seasonably pay all assessments that may be imposed by said company for the purposes aforesaid as above agreed.

XII. In case the second part ——, legal representatives, heirs or assigns, shall pay the several sums of money punctually, and at the times above limited, and shall strictly and literally perform all and singular the agreements and stipulations aforesaid after their true tenor and intent, then this contract shall be and operate as a contract entitling said second part— in perpetuity to the enjoyment of the right hereby granted, subject, however, to the same assessments and forfeitures for non-payment as herein provided.

XIII. And it is hereby agreed and covenanted by the parties hereto that time and punctuality are essential elements of this contract. And in case the second part— shall fail to make the payments aforesaid, and each of them, or shall fail to pay any assessment which may be levied as provided in paragraphs V and VI hereof, punctually and upon the strict terms and times above limited for the payments and assessments herein provided for, or likewise to observe, perform, and complete, all and each of said agreements and stipulations aforesaid strictly and literally, without any failure or default, then this contract, so far as it may bind the first party, shall become null and void, the water may be immediately shut off, and all rights and interests hereby created or then existing in favor of the second part,—, —— heirs or assigns, or derived from this contract shall utterly cease and determine, and all equitable and legal interest in the right hereby contracted for shall revert to and revest in said first party, without any declaration of forfeiture or any other act of said first party to be performed, and without any right of said second part—of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made: *Provided*, That said first party shall give to said second part— heirs or assigns, sixty days' notice, either personal or by mail, of the said second part—, —— heirs or assigns, being in arrears upon said payments, or any of them, or the interest thereon, which notice, if by mail, shall be sufficient, if by registered letter addressed to said second part— at ——— Colorado.

XIV. It is also stipulated and agreed that no assignment of the rights of the second part— under this contract, whether by conveyance or lease of all or part of said lands, or by operation of law, or otherwise, shall be binding on the first party, so as to require it to carry for or deliver to such assignee any of the amount of water herein contracted to be carried and delivered unless the first party shall consent thereto in writing; and provided, that no assignment whatever shall be binding as to the first party herein until the same is endorsed upon these presents and consented to in writing upon these presents by the said company: *And provided further*, That nothing herein contained shall be taken to bind the party of the first part herein to release the second part— in case of such assignment, from any liabilities to said first party under this contract. The endorsement upon these presents of the company's consent to the assignment by the party— of the second part of this contract and of —— rights hereunder will be made by said company upon request of the part— of the second part, provided all payments, assessments, and charges herein provided for which may have become due at or prior to the time of such request shall have been fully paid.

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XV. It is further stipulated and agreed that nothing in the foregoing provisions as to relocation and assignment shall be taken to bind the first party to convey or deliver water in less amount than 5 statutory inches for any one tract of land.

XVI. It is also stipulated and agreed that from and after the execution hereof, the said second part— may enter into the use and enjoyment of water flowing through said canal, its reservoirs or laterals, to the extent of the rights above contracted for as fully as though fully paid for, but subject, however, to all the terms, limitations, and conditions above set forth.

In witness whereof, the —— —— Canal Company, party of the first part, has hereunto caused its corporate name to be subscribed by its president, and attested by its secretary, and its corporate seal to be affixed hereto as well as to a duplicate hereof, and the part— of the second part— hereunto subscribed — name— and affixed — seal— hereto, as well as to a duplicate hereof, this the — day of —— A. D. 18—

—— —— COMPANY.

By —— —— *President.*

Attested by:

—— —— *Secretary*

—— —— [SEAL.]

Address, —— ——

—— —— [SEAL.]

Address, —— ——

ASSIGNMENT.

—— ——, the within-named purchaser, for and in consideration of —— dollars, do hereby assign and transfer all — right, title, interest, and claim in and to the within-described rights to water unto —— ——, of ——, county of —— and State of ——, heirs and assigns, forever; and — do hereby authorize and empower the —— —— Company to receive from the said —— —— all unpaid balances due to said company, in part consideration for said water rights.

Given under — hand and seal this — day of ——, A. D. 18—.

It is expressly understood that in consenting to recognize this assignment the officers of this company do not exempt the original purchaser from any of his liabilities under the contract, but will protect the rights of the assignee, provided he complies with its obligations.

—— ——. [SEAL.]

Countersigned.

—— ——,
President.

—— ——,
Secretary.

STATE OF COLORADO,
County of ——, ss:

Before me, —— —— in and for said county, this day personally came —— ——, known to me to be the identical person described in the within agreement, and who executed the foregoing assignment, and acknowledged that — signed, sealed, and delivered the same as — free and voluntary act and deed, for the uses and purposes therein set forth.

Given under my hand and — seal of office this — day of ——, A. D. 18—.

—— ——.

My commission expires ——, 18—.

Received ——, 189—, of —— —— the sum of —— dollars, amount of first deferred payment, on the within contract.

—— ——.

[Receipts similar to the above for the second to the eighth payments, inclusive, follow.]

(Indorsement:) No.—. Agreement to carry — inches of water. The —— —— with —— ——.

No. II.

Know all men by these presents, that the —— —— Canal Company, a corporation existing under the laws of the State of Colorado, of the first part, and —— ——, of the county of —— and State of Colorado, of the second part, for and in consideration of the sum of $— to be paid as hereinafter specified, and in consideration of the mutual covenants and agreements in this contract contained, to be per-

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formed and kept, the said company hereby agrees to sell unto the second party a water right for —— statutory inches of water flowing through the canal of said company, subject to the following terms and conditions, to which the said party of the second part, —— heirs and assigns, hereby expressly agree:

I. The said company agrees to furnish the said water to the said second party, —— heirs or assigns, continuously during the irrigating season, except as hereinafter provided, and at no other time, unless with the consent of said company thereto in writing.

II. Said water shall be used only for irrigating and domestic purposes on the following described tract of land, and none other, to wit: ——— ——— and under no circumstances shall said water, or any portion thereof, be used for mining, milling, or mechanical power, or for any other purpose not directly connected or incident to the purposes hereinafter specified.

III. Said company expressly reserves to itself the right to distribute the water from its said canal in accordance with such rights and priorities as are or may hereafter be established or decreed; and this deed is received by the party of the second part subject to such priorities.

IV. The said second party, —— heirs or assigns, shall not permit said water, nor any portion thereof furnished as aforesaid, to run to waste, but as soon as a sufficient quantity shall have been used for the purposes herein allowed and contracted for, the said second party, —— heirs or assigns, shall shut off said water and keep the same shut and turned off until the same shall be again needed for the purposes aforesaid. But in no case shall the amount of water taken or received by said second party, —— heirs or assigns, exceed the quantity first herein referred to, and said company hereby reserves the right at any time to shut off the water herein mentioned whenever it shall find that the said part— of the second part —— wasting it or not using it on the land above-mentioned.

V. The said company shall deliver said water at such point or points along the line of said canal or ditch, or from any of its reservoirs, laterals, either or all, as it may determine to be the most practicable, and the manner of withdrawing and regulating the supply of said water from said company's ditch and reservoirs shall be prescribed by said company, and shall at all times be under its control, as determined and directed by the said company. The head-gates, flumes, weirs, or other arrangements or devices through which the water hereby sold shall be drawn from said company's ditch or reservoirs, shall be made and placed in position by the said company, but at the cost of said second part— who shall also be liable for the expense of keeping the same in good repair and condition; and the said company may collect and enforce the payment of all sums expended for said purposes in the same manner as prescribed for collecting and enforcing assessments.

VI. The said first party agrees to keep and maintain said main canal or ditch and any and all of its reservoirs and laterals in good order and condition, and in case of accident to the same, to repair the injury thereby occasioned, as soon as practicable and expedient; and the company shall have a right to assess the said second part— for its expenses of maintaining, repairing, and operating said canal and any and all reservoirs and laterals connected therewith, including taxes and legal assessments on said canal, a sum not exceeding —— per statutory inch hereby contracted to be supplied per annum; and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights, pro rata, such sums as may be necessary to repair the injuries so occasioned. The amount of all assessments herein provided for shall be determined and levied by said company by resolution of its board of directors, and the company also reserves to itself the right by like resolution to establish and enforce such rules and regulations, and to provide and declare such penalties as it may deem necessary and expedient for the purpose of enforcing and collecting said assessments, or any part thereof. Said assessments shall be due and payable at such time as may be fixed by the board of directors of the first party, and the second part— hereby agree— to duly pay the same, and further agree— that the failure to pay the same or any part thereof within sixty days after notice of the levy of any assessment (which notice may be either personal or by registered letter addressed to the second party at ———, Colorado) shall, at the option of the board of directors of the first party, constitute a forfeiture of all the rights of the second part— as provided in paragraph XIV of this agreement.

VII. The said first party shall have, and the said second part— hereby grant— to the said first party, a right of way across said above described land of the width of ——— for the main canal or laterals of said first party as now located, and also the right of roadway on the banks of the canal and main laterals; and in case a fence is constructed by said second part— across said roadway —— shall construct and maintain a gateway across said bank, when said first party requests, in which case said first party shall close said gate when opened by it.

VIII. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the first party shall be unable to carry and distribute a volume

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of water equal to the estimated capacity of its canal, either from casual, unforseen, or unavoidable accidents, or from any cause beyond the control of said first party, or if the volume of water prove insufficient from drouth or from any other cause beyond the control of said company, the company shall not be liable in any way for the shortness or deficiency of supply so occasioned, or any loss or damage resulting therefrom, by reason of any of said causes. If, however, by reason of such causes, or any of them, the supply of water be insufficient to furnish an amount equal to all the water rights then outstanding, the said company shall have the power and the right to distribute such water as may flow through said canal to the holders of such water rights pro rata, or may alternate the same; and for the purpose of so doing may establish and enforce such rules as it may deem necessary or expedient. And the second part— for ——— and —— heirs and assigns, agree—, in consideration aforesaid, to waive, and hereby do waive, any claim for loss or damage by reason of any leakage, overflow, or breaking of said company's canals, or any of its reservoirs, lakes, or laterals, either upon the land aforesaid or any other tract belonging to the part— of the second part.

IX. The said company agrees that when it shall have sold and have outstanding and in force a number of water rights equal to the estimated capacity of the company's canal, or sooner at its option, it will then transfer to the holder of each water right, who shall have complied with the terms and conditions of this contract without further consideration, such a proportion of the number of the shares of the capital stock of the said ——— ——— company as the number of water rights held by —— bears to the whole number of water rights held or outstanding in the canal of the company, or as near thereto as may be possible without making fractions of shares, and which said shares the second part — agree— to accept: *Provided however*, That such transfer is to be made only on the express condition that the first party shall thereupon and thereafter be absolutely released from any and all obligations or liabilities arising out of the ownership, operation, management, or control of said canal, or out of any contract (including this) pertaining to the distribution of water therefrom, which said obligations shall be assumed by said holders of water rights, who shall pay all expenses incident to such transfer; which said condition the said second part— in consideration thereof and of these presents, for ——— and —— heirs and assigns do— hereby accept. Such transfer shall only be made when the canal is in good order and unencumbered.

X. It is further agreed that the irrigating season shall commence April 15 and continue to November 1 of each and every year, and that thereafter water shall be conveyed for domestic purposes whenever reasonably practicable; subject to the right of said first party to shut off the water in order to repair or enlarge or extend said canal.

XI. The payment of the consideration heretofore specified herein shall be as follows: —— dollars upon the ensealing and delivery of this contract, payment of which is hereby acknowleged, and the balance in —— payments at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment....							
Second deferred payment..							
Third deferred payment...							
Fourth deferred payment..							
Fifth deferred payment....							
Sixth deferred payment....							
Seventh deferred payment.							
Eighth deferred payment..							

Said deferred payments shall bear interest at the rate of —— per cent. per annum, payable annually, and shall bear interest after maturity at the rate of —— per cent. per annum, and the second part—, in consideration of the premises, hereby agree— that —— will make punctual payment of the above sums, and each of the same, together with the interest thereon, as the same respectively become due; and that —— will regularly and seasonably pay all assessments that may be imposed by said company, for the purposes aforesaid, as above agreed.

XII. In case the second part —— legal representatives, heirs or assigns, shall pay the several sums of money punctually, and at the times above limited, and shall strictly and literally perform all and singular —— agreements and stipulations aforesaid after their true tenor and intent, then the first party shall cause to be made and executed unto the second part —— heirs or assigns, a deed conveying the water-right above described in fee-simple; subject, however, to the same assessments and forfeitures for non-payment as herein provided.

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XIII. The first party claims and reserves a strip of land of the width necessary and sufficient for the right of way of the canals of the first party, and for enlarging and repairing and superintending the same where any such canal is located upon or contiguous to the premises, hereby claiming and reserving the right of way across said lands for lateral canals where the same are or may become necessary and expedient for the purpose of conveying water from the main canals of first party to the lands below, whether such laterals are constructed by the first party, or by persons owning such lower lands; provided that the laterals aforesaid shall be constructed under the supervision of and upon such lands only as are selected by the first party.

XIV. And it is hereby agreed and covenanted by the parties hereto that time and punctuality are essential elements of this contract. And in case the scond part— shall fail to make the payments aforesaid, and each of them, or shall fail to pay any assessment which may be levied, as provided in paragraphs V and VI hereof, punctually and upon the strict terms and times above limited for the payments and assessments herein provided for, or likewise to observe, perform, and complete all and each of said agreements and stipulations aforesaid strictly and literally without any failure or default, then this contract, so far as it may bind the first party, shall become null and void, the water may be immediately shut off, and all rights and interests hereby created or then existing in favor of the second part —— heirs or assigns, or derived from ——— ——— shall utterly cease and determine, and all equitable and legal interest in the water-right ——— ——— hereby contracted to be conveyed shall revert to and revest in said first party, without any declaration of forfeiture or any other act of said first party to be performed, and without any right of said second part— of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made: *Provided*, That said first party shall give to said second part—, —— heirs or assigns, sixty days' notice, either personally or by mail, of the said second part —— heirs or assigns, being in arrears upon said payments, or any of them, or the interest thereon, which notice, if by mail, shall be sufficient, if by registered letter addressed to said second part— at ——, Colorado.

And it is further stipulated that no assignment of the premises shall be valid unless the same shall be indorsed hereon, and no agreements, or conditions or relations between the said second part— and —— assigns, or any other person acquiring title or interest from or through ——, shall preclude the first party from the right to convey the premises to the second part— or —— assigns, on the surrender of this agreement and the payment of the unpaid portion of the purchase money which may be due to the first party.

XV. It is also stipulated and agreed that from and after the execution hereof, the said second part — may enter into the use and enjoyment of water flowing through said canal, its reservoirs or laterals to the extent of the right, above contracted to be conveyed, as fully as though fully paid for, but subject, however, to all the terms, limitations and conditions above set forth.

In witness whereof, the ——— ——— Company, party of the first part, has hereunto caused its corporate name to be subscribed by its president, and attested by its secretary and its corporate seal to be affixed hereto as well as to a duplicate hereof, and the part— of the second part ——— ——— subscribed ——— ——— name— and affixed —— seal— hereto, as well as to a duplicate hereof, this the —— day ——— A. D. 18—.

——— ——— COMPANY,
By ——— ——— *President.*

Attested by—

——— ——— *Secretary.*
——— ——— [SEAL.]
Address: ——— ———
——— ——— [SEAL.]
Address: ——— ———
——— ——— [SEAL.]
Address: ——— ———

ASSIGNMENT.

———— ————, the within-named purchaser, for and in consideration of ——— dollars, do — hereby assign and transfer all —— right, title, interest and claim in and to the within-described rights to water unto ——— ——— of ———, county of ———, and State of ———, heirs and assigns, forever. And —— do — hereby authorize and empower the ——— ——— Company, to receive from the said ——— ——— all unpaid balances due to said Company, in part consideration for said water rights and upon the final payment of all the purchase money and a full compliance of all the require-

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ments contained in the within agreement, to execute, or cause to be executed, to the said —— —— heirs and assigns, a deed of said water rights, instead of to ——.

Given under —— hand and seal, this —— day of ——, A. D., 18—.

It is expressly understood that in consenting to recognize this assignment, the officers of this Company do not exempt the original purchaser from any of his liabilities under the contract, but will protect the rights of the assignee, provided he complies with its obligations.

—— ——, [SEAL.]

Countersigned:

—— ——,
President.

—— ——,
Secretary.

STATE OF COLORADO,
County of ——, ss.

Before me —— ——, in and for said county, this day personally came —— ——, known to me to be the identical person— described in the within agreement, and who executed the foregoing assignment, and acknowledged that —— signed, sealed, and delivered the same as —— free and voluntary act and deed, for the uses and purposes herein set forth.

Given under my hand and —— seal of office, this —— day of ——, A. D. 18—.

My commission expires ——, 18—.

—— ——.

Received ——, 189—, of —— —— the sum of —— dollars, amount of first deferred payment on the within contract.

—— ——.

[Receipts similar to the above for the second to the eighth payments, inclusive, follow.]

(Indorsement.) No. ——. Agreement for sale of water right. The —— —— with —— —— for —— statutory inches.

No. III.

THE FORT MORGAN LAND AND CANAL COMPANY.

This agreement, made this —— day of ——, in the year 18—, between the Fort Morgan Land and Canal Company, a corporation existing under the laws of the State of Colorado, as the first party, and —— ——, of the county of Weld, and State of Colorado, as the second party, witnesseth:

I. That in consideration of and subject to the stipulations herein contained, and the payments to be made as hereinafter specified, the first party hereby agrees to sell unto the second party —— heirs or assigns, —— water right —— to the use of water, flowing through the canal of said first party; each water right to be sufficient to irrigate 80 acres of land, but not to exceed 1.40 cubic feet of water per second of time, which the first party agrees to furnish to the second party —— heirs or assigns, during the irrigating season, except as hereinafter provided, and at no other time, for domestic purposes and for irrigating the following-described land, situate in the county of Weld, and State of Colorado, viz: —— ——.

II. Said second party —— heirs or assigns, shall not permit said water or any portion thereof, furnished as aforesaid, to run to waste, provided, however, that owners of water rights from the said canal may temporarily, for mutual convenience for irrigating purposes only, use their water in combination upon their several lands, but never upon lands for which the first party has not sold its full quota of water, on a basis of one water right to 80 acres of land.

III. Said first party shall deliver said water at such point or points along the line of said canal, or from any of its reservoirs, either or all, as it may determine from time to time to be most practicable; and the location of all headgates, and the manner of withdrawing and regulating the supply of water from said company's canals and reservoirs, shall be prescribed by said company, and shall at all times be under its control.

IV. Said first party agrees to keep and maintain said canal and any and all of its reservoirs in good order and condition, and in case of accident to the same to repair the injury thereby occasioned as soon as practicable and expedient; and the company shall have a right to assess said second party, for the expense of maintaining, repairing and superintending said canal and any and all reservoirs connected therewith, a sum

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not exceeding $10 per water right sold, per annum, and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights pro rata such sums, not exceeding $10 in any one year for each water right, as may be necessary to repair the damages so occasioned. The amount, manner of collection, and time of payment of all assessments herein provided for shall be determined by said company; and the company also reserves to itself the right to establish and enforce such rules and regulations, and to provide and declare such penalties as are necessary and expedient for the purpose of enforcing and collecting said assessments, or any part thereof.

V. It is further expressly understood and agreed that when the first party shall have sold and have outstanding and in force water rights, fully paid up, equal to the full capacity of its canal (or sooner at its option), it will distribute pro rata the stock of said company among the holders of water rights so sold and the first party as owners of unsold water rights (if any), and the second party agrees to merge —— water right —— in this contract, and the first party, in the exercise of said option, to merge all its water rights then remaining unsold, if any, severally, into the capital stock of said company, in equitable proportions to the water right— so merged.

VI. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the canal of said first party shall be unable to convey and distribute a volume of water equal to the estimated capacity, either from any accident, or from lack of supply in the South Platte River, or from any other cause beyond the control of said first party, then the first party shall not be liable for the shortness or deficiency of supply so occasioned, or any losses or damages resulting therefrom. It is further agreed that during a deficiency in the water supply of such canal, from any of the causes aforesaid, the first party shall have the right to divide the diminished supply pro rata, among the holders of water rights under said canal, and for the purpose of so doing may establish and enforce such rules and regulations as are necessary and expedient. And the second party, for —— and —— heirs and assigns agree— in consideration aforesaid to waive, and do hereby waive, any claim for loss or damage by reason of any leakage or overflow of said canal, or any of its reservoirs, lakes, or laterals, not resulting from the negligence of the first party, either upon the land aforesaid or any other tract belonging to said second party.

VII. In consideration of foregoing promises, covenants, and agreements of the said party of the first part, the second party agrees to pay unto the said first party the sum of ——— dollars with interest, payable annually, at the rate of 10 per cent. per annum. Payment has been made and received of ——— dollars, and the remaining principal, with the annually accruing interest, shall be paid at the office of the first party in Denver, Colo., in ——— payments, at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment....	.....	.....	.....	.....	.....	.....	.....
Second deferred payment..	.....	.....	.....	.....	.....	.....	.....
Third deferred payment...	.....	.....	.....	.....	.....	.....	.....
Fourth deferred payment..	.....	.....	.....	.....	.....	.....	.....
Fifth deferred payment....	.....	.....	.....	.....	.....	.....	.....
Sixth deferred payment....	.....	.....	.....	.....	.....	.....	.....

And the second party, in consideration of the premises, hereby agrees that —— will make punctual payments of the above sums, as each of the same respectively becomes due, and that —— will regularly and seasonably pay all assessments that may hereafter be imposed by said company for the purposes aforesaid. And when the said party of the second part or —— assigns, shall have fully paid the consideration for the water rights herein conveyed, with interest thereon according to the terms of this contract, the absolute title to said water rights, free and clear of all incumbrances, shall be thereby vested in the said party of the second part, and his assigns without any further or other deed of conveyance whatsoever.

VIII. The second party for —— heirs and assigns further agree— to pay to the first party or its assigns, on such terms and regulations as its board of trustees may from time to time prescribe and determine —— proportional part of the expenses of maintaining and repairing the general fence, constructed to inclose a large tract of land lying under said canal; and said second party for —— heirs and assigns further expressly agrees, in consideration of these presents, that —— will not permit any live stock in —— possession or under —— control to run at large within such general fence; and any violation of this agreement shall render the second party —— personal representatives or assigns, liable in damages to the first party, as trustee for the benefit of any persons and their privies in interest, who may be injured by reason of depredations of live stock so allowed to run at large in violation hereof.

IX. And it is hereby covenanted and agreed by the parties hereto, that time and

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punctuality are material and essential elements of this contract, and that in case said party of the second part shall fail or neglect to make the payments aforesaid, and each of them, at the time and times herein stipulated, then all rights, privileges, and benefits accrued or accruing under the terms of this contract in favor of said party of the second part or —— heirs or assigns, shall utterly cease and determine after thirty days' notice of such default being given by deposit thereof in the post-office at Denver, addressed to said party of the second part at his last known post-office address, or by personal service of such notice, at the option of said party of the first part, and without any right of said party of the second part of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made; and all moneys theretofore paid by said party of the second part to said party of the first part under the provisions of this contract shall belong to, and be retained by, said party of the first part as liquidated damages for the breach hereof.

It is further expressly and distinctly agreed and understood that this contract shall not be construed or operate to convey or vest any interest whatever in the water right hereinbefore mentioned until said party of the second part shall have fully performed each and every of the covenants and agreements herein contained, for the payment of the aforesaid consideration and purchase price, and shall not be assigned until fully paid up, without the consent of the first party indorsed hereon.

In witness whereof, The Fort Morgan Land and Canal Company has hereunto caused its corporate name to be subscribed by its president and attested by its secretary and its corporate seal to be affixed, and the second party —— subscribed —— name and affixed —— seal hereto, the day and year first above written.

THE FORT MORGAN LAND AND CANAL COMPANY,
By ——— ———,
President.

Attested by:

———— ————,
Secretary.

——— ——— [SEAL.]
——— ——— [SEAL.]
——— ——— [SEAL.]

ASSIGNMENT.

———— ————, the within named purchaser, for and in consideration of ——— dollars, do— hereby assign and transfer all —— right, title, interest, and claim in and to the within described rights to water unto ——— ———, of ———, county of —— and State of ———, heirs and assigns forever. And —— do— hereby authorize and empower The Fort Morgan Land and Canal Company to receive from the said —— ——— all unpaid balances due to said company, in part consideration for said water rights, and upon the final payment of all the purchase money, and a full compliance with all the requirements contained in the within agreement, to execute, or cause to be executed, to the said ——— ———, heirs and assigns, a deed of said water rights, instead of to ——— ———.

Given under —— hand— and seal— this —— day of ———, A. D. 18—.

It is expressly understood that in consenting to recognize this assignment, the officers of this company do not intend to exempt the original purchaser from any of his liabilities under the contract, but to protect the rights of the assignee, provided he complies with its obligations.

——— ———. [SEAL.]

Countersigned:

———— ————,
President.

———— ————,
Secretary.

STATE OF COLORADO,
County of ———, *ss:*

Before me, ——— ———, in and for said county, this day personally came —— ———, known to me to be the identical person— described in the within agreement, and who executed the foregoing assignment, and acknowledged that —— signed, sealed, and delivered the same as —— free and voluntary act and deed for the use and purposes herein set forth.

Given under my hand and —— seal of office this —— day of ———, A. D. 18—.

———— ————.

Received ——— 18 —, of ——— ———, the sum of ——— dollars, amount of first deferred payment on the within contract.

———— ————.

[Receipts similar to the above for the second to the sixth, inclusive, follow.]

(Indorsement:) No. ——— Agreement for sale of water right. The Fort Morgan Land and Canal Company with ——— ———.

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AREAS UNDER DITCH AND CULTIVATED.

STATISTICS OF RECLAMATION IN ARIZONA, CALIFORNIA, COLORADO, IDAHO, KANSAS, MONTANA, NEBRASKA, NEVADA, NEW MEXICO, OREGON, SOUTH DAKOTA, UTAH, WASHINGTON, AND WYOMING.

PART IV.

Reliable statistics of irrigation are as yet unknown. Approximate statements, reasonably correct, are all that can be now obtained. The recent (1889) investigation of the United States Senate special Committee on Irrigation and the Reclamation of Arid Lands have given a basis for statements before impossible, in spite of statements that have been widely published that inquiries have been made and data collected under official scientific direction for the past ten years. Nothing of the sort has been done, except as a very general incidence of certain geological and topographical work carried on in the arid West.

The first real attempt to obtain data on American irrigation was made in the preparation of this report, when in 1884–'85 the Department of Agriculture authorized such inquiry under the editor of this report. In 1886 the Senate directed the publication of a first edition thereof. In the following session of Congress an inquiry was ordered. In the following year an appropriation of $100,000 was made for the purpose of organizing an irrigation survey. The next session that appropriation was increased to $250,000, making in all $350,000 up to the date of this publication.

The Senate, upon the motion of Hon. William M. Stewart, of Nevada, appointed a special committee to investigate the subject, Mr. Stewart being made chairman. On the 1st of August, 1889, at St. Paul, Minn., the field inquiry began. In the following fifty-two days the committee visited eighteen States and Territories, held fifty-eight sessions, heard several hundred witnesses, traveled in all over 15,000 miles, closing their inquiry at Washington; holding eight sessions there for testimony and hearing there eighteen witnesses in all; a majority and minority report was made; bills introduced, and four volumes of testimony, covering in all 1,990 pages, were printed.

The following tabulations then are quoted from the report of the majority, with additional data presented by other authorities.

Beginning with the Dakotas, it is estimated that there are about 100,000 acres "under ditch" in southwest Dakota—that is the Black Hills section—of which about 15,000 acres are under cultivation, the balance being in grass.

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Irrigation ditches and areas in Idaho.

Counties in which irrigation now exists.	No. of completed ditches.	Ditches.	Irrigated in 1889.	Estimated No. of acres irrigable.
		Miles.	*Acres.*	
Ada	*62	*448	60,000	900,000
Alturas	10	18	14,500	118,000
Bear Lake	69	206	21,500	39,000
Bingham, north	†16	253	245,000	2,236,000
Bingham, south	70	264	39,250	267,500
Boisé	†20	60	83,500	.....
Cassia	298	299	82,000	656,400
Elmore	†50	†25	10,000	230,000
Logan	†65	‡125	50,000	1,250,000
Lemhi	250	‡300	9,715	500,000
Oneida	†65	‡100	38,760	196,000
Owyhee	66	153	21,275	248,500
Washington	†270	§34 ‡133	40,000	500,000
Total	1,311	2,418	715,500	7,141,400

* This includes three ditch systems, embracing 207 miles, incompleted when estimates were made.
† The sixteen ditches given do not include the laterals. At an average estimate of 400 acres per ditch the mileage would be over 600.
‡ Estimated on the basis of 2 miles per ditch serving 400 acres. This is near enough for an approximate estimate, below rather than above the facts.
§ The 34 miles are the definite lengths given of new ditch systems; the balance is an estimate.

The Geological Survey estimates 740,350 acres as irrigated in 1889.

The Society of Civil Engineers presented for Montana a report which is tabulated as follows:

Irrigation ditches and areas in Montana.

No.	County.	Area.	Supposed under cultivation.	Supposed can be cultivated by irrigation.
		Sq. miles.	*Acres.*	*Acres.*
1	Beaver Head	3,740	80,000	250,000
2	Cascade	2,570	50,000	600,000
3	Choteau	24,830	50,000	5,000,000
4	Crow Reservation	7,830	.....	1,500,000
5	Custer	22,300	30,000	3,000,000
6	Dawson	25,650	50,000	4,000,000
7	Deer Lodge	4,760	100,000	350,000
8	Fergus	7,415	100,000	1,500,000
9	Gallatin	2,900	100,000	400,000
10	Jefferson	2,060	25,000	250,000
11	Lewis and Clarke	1,760	50,000	400,000
12	Madison	4,546	100,000	400,000
13	Meagher	7,160	35,000	500,000
14	Missoula	19,580	150,000	600,000
15	Park	4,740	15,900	500,000
16	Silver Bow	760	1,000	40,000
17	Yellowstone	3,390	50,000	500,000
	Total	146,000	986,000	19,790,000

Other statistics show that there were in 1869, of mining ditches 287½ miles constructed, at a cost of $806,500. The present extent, including these—as many have been used for irrigation purposes also—is now estimated at 1,000 miles. There are now partially or wholly completed the following larger or district systems, constructed for rental investment by corporations:

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Corporation ditches.	Miles.	Acres to be served.	Estimated cost.
Benton Lake	35	50,000	$175,000
Clarke's Fork	38	100,000	140,000
Chestnut Valley	10	25,000	7,000
Dearborn	45	51,000	150,000
Florence	50	10,000	200,000
Gallatin	25	50,000	75,000
Sun River	75	300,000	500,000
Teton	40	35,000	80,000
Total	318	611,000	1,327,000

Report to the U. S. Geological Survey by R. S. Tarr, estimates 500,000 acres under cultivation. Assessors return made the total 348,102 acres. The statistics of the committee show the following:

Irrigation ditches and areas in Utah.

Counties reported.	Irrigated areas in acres. 1889.	No. of canals.	Miles of canals.
Beaver	9,500	*32	*96
Box Elder	17,500	12	*76
Cache	41,444	40	110
Emery	14,825	*34	102
Garfield	5,000	*17	*51
Iron	6,997	*23	*69
Juab	4,000	*13	*39
Kane	1,825	9	*18
Millard	13,500	42	*120
Morgan	8,648	*29	*87
Pi Ute	12,135	31	*93
Rich	42,811	*143	*429
Salt Lake	38,587	37	*213
San Juan	1,025	4	12
San Pete	3,500	*12	*36
Sevier	17,619	*60	*180
Summit	8,500	*28	*84
Tooele	6,250	*21	*63
Uintah	8,933	*30	*90
Utah	69,126	*346	*1,488
Wasatch	18,000	60	180
Washington	18,892	31	186
Weber	44,052	25	5
Total	412,669	1,079	3,903

*These are estimates made on a uniform basis of 300 acres to each ditch and of laterals 3 miles in length.

The Mormon Church returns of irrigation quoted by Major Powell, for 1889, puts the land "under irrigation" at 802,456 acres, that is, "under ditch." Actually irrigated that year the area is given at 371,437 by farming 66,191 arable, but not irrigated 2,525,403 acres.

For Oregon, estimates of the U. S. Geological Survey presented by the Director to the committee are here given:

Irrigation ditches and areas in Oregon.

[Report of W. G. Steel, June 27, 1889.]

County.	Irrigated.	Under ditches.	County.	Irrigated.	Under ditches.
	Acres.	*Acres.*		*Acres.*	*Acres.*
Baker	5,000	10,000	Malheur	40,000	60,000
Crook	8,000	8,000	Morrow	6,000	18,500
Gilliam	3,000	5,000	Umatilla	5,000	7,000
Grant	10,000	10,000	Union	5,000	8,000
Harney	20,000	20,000	Wallowa	7,000	10,000
Klamath	5,000	30,000			
Lake	5,000	5,000	Total	119,000	191,500

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Eastern Washington's irrigated area is given by the committee at 75,000 acres "under ditch," and 50,000 acres as irrigated. That of Nevada is stated at 142,000 acres under ditch, of which 75,000 are cultivated by irrigation.

For the Golden States returns are conflicting, but the following is a fair statement of—

*Irrigation ditches and areas in California.**

	Ditches.	Cost per mile.	Total cost.
	Miles.		
In the San Joaquin Valley, counties of Fresno, Merced, Kern, and Tulare	800	$5,400	$4,320,000
In the counties of Los Angeles, Orange, and San Bernardino	500	6,000	3,000,000
In San Diego County	36	19,613	706,068
In the remaining part of the State, twenty-four counties, where irrigation is practiced	1,700	640	1,128,000
Counting one-third of the mining ditches in the State as available and used for small irrigation, we have	289	3,188	921,221
Total	3,825		10,375,289

Without question the total valuation or cost is much below the true figures. Much of the data on which the estimates are based is taken from the assessors' returns made for the purpose of taxation. They can therefore be doubled. That will give a total cost of at least $20,000,000.

The acreage is as difficult to arrive at with certainty, but it can be fairly and moderately stated as follows:

	Acres.
In the San Joaquin counties:	
In farm crops	1,000,000
In vines	13,000
In fruit trees	16,000
	1,029,000
In the southern counties:	
In farm crops	580,000
In vines	45,000
In fruit trees	85,000
	710,000
In the balance of State (irrigated):	
In farm crops	1,500,000
In vines	25,000
In fruit trees	30,000
	1,555,000

The total acreage wholly under ditch and now irrigated is fairly within the annexed totals:

	Acres.
In farm crops	3,080,000
In vines	83,000
In fruit trees	131,000
Total	3,294,000

If all the areas directly cultivated by the aid of natural subirrigation, etc., be added, the total area in California will certainly be not less than 3,500,000 acres. The point of interest, however, in these figures is the profitable character of such cultivation, especially in the matter of fruit-raising.

* From report of majority of Senate Committee on Irrigation, 1890.

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Major Powell's statement, from "Irrigation in United States," first edition, 1886, gives these figures—

	Acres.
Under ditches, constructed or projected	6,000,000
Irrigated, etc.	3,000,000

The same authority reports the following—

Irrigation ditches and areas in Arizona.

County.	No. of canals.	Length.	Area under ditch.
		Miles.	*Acres.*
Apache		24½	12,500
Cochise		51	8,300
Graham		60	35,000
Maricopa	23	304½	194,400
Pima	36	52	30,000
Pinal	28	50	78,000 * 50,000
Yavapai		78	40,000
Yuma	10	120½	81,000
Total		740½	529,200

* In Pima Reservation.

These figures are entirely taken from county reports. The ditch system constructing in Yuma County will, when completed, have a total length of 241 miles and an acreage of 207,000. The total cost will be $1,318,000, or nearly $5,500 per mile. The canals under way in Maricopa County will, when completed, cover 404,900 acres and have a total length of 425 miles. Apache County reports 150,000 acres reclaimed, Pima County 2,500,000 acres, and Cochise 310,000 acres. Of the area "under ditch" about two-thirds are actually cultivated. For Arizona the Geological Survey estimates all reclaimable, 1,650,000 acres; under ditch, 455,600 acres; actually cultivated, 203,080 acres. Engineer Newell for the same territory estimates only 175,000 acres as cultivated through irrigation.

Western Texas, that is the arid section west of the one hundredth meridian, has been making rapid strides. Its total area irrigated and under ditch, after careful inquiry is placed at 200,000 acres "under ditch" and 125,000 actually cultivated.

Southwest Kansas in 1889 suffered largely from the drought. "Under ditch" were 300,000 acres, nearly all in the Upper Arkansas Valley, while but 75,000 acres were cultivated by actual irrigation.

The following table gives the official census figures of 1885:

Irrigation ditches and areas in New Mexico.

Number of farms	10,511
Number of acres (improved, estimated)	500,000
Area reclaimable in acres	13,965,000

Under date of June 24, 1889, T. B. Mills, of Las Vegas, N. Mex., makes the following estimate:

County.	Under ditch.	County.	Under ditch.
	Acres.		*Acres.*
Bernalillo	12,421	Santa Fé	9,820
Colfax	133,400	Sierra	8,673
Doña Aña	37,621	San Juan	20,000
Grant	8,721	Socorro	73,464
Lincoln	100,000	Taos	88,763
Mora	51,279	Valencia	26,429
Rio Arriba	29,623		
San Miguel	38,241	Total	638,455

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Projected ditches and ditches under construction will serve in addition, 722,000 acres.

A most careful student and engineer, L. G. Carpenter, professor of irrigation engineering and meteorologist in the State Agricultural College, presented in his annual college report (January, 1890) the following approximate estimate of—

Irrigation ditches and areas in Colorado.

	Area.	Total area.	
Division I (Platte Division):	*Sq. miles.*	*Sq. miles.*	*Acres.*
Platte Valley, below the Poudre	283.21		
Platte Valley, above the Poudre, including Bear and Clear Creeks	551.64		
St. Vrain and Boulder Creeks	294.59		
Big and Little Thompson	134.22		
Cache La Poudre	393.54		
Total from South Platte		1,657.20	1,060,608
From North Platte in North Park		101.23	64,787
Division II (Arkansas Division):			
East of the Huerfano River	489.08		
Cucharas	94.40		
La Veta and Apache	84.17		
Upper Arkansas and Fontaine	106.91		
		774.56	495,718
Division III (Rio Grande Division)		1,564.00	1,000,960
Division IV (San Juan Division), including Dolores, Mancos, Pine, Florida, La Plata Rivers		135.00	86,400
Division V (Grand River Division)		210.00	134,400
Division VI (Bear and White River Division)		110.00	70,400
Total		4,552.00	2,913,273

By this table the total amount of land under ditch in Colorado at present is not far from 4,500 square miles, or 3,000,000 acres. The amount of land actually irrigated can not be so reliably estimated at present. It is much less than that under ditch.

Professor Carpenter estimates the total irrigated as not over one-third. This is apparently below the actual results. State Engineer Maxwell reported the following figures as a careful statement of the area east of the Rocky Mountains:

Divisions.	No. of districts.	Miles of ditches.	Acres.	
			Under ditch.	Actually irrigated.
No. 1 Platte	14	2,067.36	1,126,800	631,036
No. 2 Arkansas	13	943.30	440,240	116,047
No. 3 Rio Grande	8	1,033.68	596,097	250,263
Total	35	4,044.34	2,163,137	997,346

In the three eastern divisions there are also one hundred and sixty-two reservoirs, with a record capacity of 5,319,939,788 cubic feet, capable of furnishing 1 acre-foot of water to each of 122,199 acres. The total number of ditches, large and small, in the State is estimated at 2,000, and their mileage at 5,000. The duty of water is placed at 1.45 cubic feet per second for 80 acres. In some sections it is over 100 acres, however.

West of the range in the Grand River, Mesa County, Uncompahgre, and other sections, there were 110,000 acres actually irrigated. The estimate of E. S. Nettleton, the leading engineer of the State, reached for 1889, one of water scarcity, to 1,300,000 acres. From the various

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enterprises now in progress and for which it is claimed water can be obtained, the area under ditch in the present will not be less than 4,000,000 acres.

There are over four hundred mountain streams within the borders of Wyoming, and the mountain area from which they flow contains at least 35,000 square miles, 22,400,000 acres. The Territorial engineer, Elwood Mead, claims as a moderate computation, that the annual precipitation on these storm-condensers and moisture-stores will average not less than 3 solid feet of water. This estimate contains 60,000,000 acre-feet; an amount sufficient, at the rate per annum of 1 acre-foot for 80 acres, to irrigate 10,000,000 acres of land. The precipitation is there, the mountains offer unequaled opportunities for storage,' the numerous watercourses can be rendered available with added artificial facilities for full distribution, and the land will present, with its broad levels and fertile qualities, an easy work for the engineer and ample return to the farmer.

Irrigation ditches and areas in Wyoming.

District.	Total No. of recorded ditches.	Total length as stated.	No. of claims, with statement of length omitted.	Total capacity as given.	No. of ditch claims, omitting statement of capacity.	Total acreage watered as given.	No. of ditch claims, omitting statement of acreage.
1*†	643	1,322.385	39	5,911.584	48	482,434.00	89
2	327	582.793	31	6,649.844	53	379,164.64	62
3	282	317.419	91	3,644.078	72	395,563.00	114
4‡							
5	502	996.398	32	10,422.700	57	440,540.00	50
6	124	196.955	46	1,556.325	36	58,162.00	55
7	322	518.240	50	1,658.906	96	108,976.78	95
8	182	212.410	52	3,095.487	79	35,396.00	96
9	49	91.430	1	342.000	25	42,460.00	3
§	7	11.905		136.800		4,180.00	
Total	2,438	4,249.935	242	20,381.723	466	1,946,875.42	564

* Engineer Mead's report.
† Seven reservoirs additional.
‡ District No. 4 omitted because of incomplete record.
§ Unorganized district.

Of this area of nearly 2,000,000 acres not more than 80,000 acres are under cultivation other than for stock purposes.

For western Nebraska, an estimate is made (1889–'90) of 50,000 acres "unditch," and 6,000 under cultivation.

The Senate committee report as follows, as a summary:

Total area under ditch and irrigated.

States and Territories.	Under ditch.	Cultivated by irrigation.
	Acres.	*Acres.*
Arizona	455,000	225,000
California	4,000,000	3,300,000
Colorado	3,000,000	1,600,000
Idaho	715,000	500,000
Kansas	300,000	75,000
Montana	986,000	350,000
Nebraska	50,000	5,000
Nevada	142,000	70,000
New Mexico	800,000	625,000
Oregon	191,000	150,000
South Dakota (Black Hills)	100,000	15,000
Texas	200,000	125,000
Utah	700,000	413,000
Washington	75,000	50,000
Wyoming	1,947,000	75,000
Total	13,661,000	7,578,000

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The table presented on the authority of the Geological Survey makes a total estimate of 8,307,000 acres, as "irrigated and under ditch;" certainly an aggregate below the fact. At date of this publication (June, 1890) the area "under ditch" west of the ninety-eighth meridian of west longitude will not be less than 16,000,000 acres in extent; under cultivation it will reach at least 9,000,000, and is probably a million more. If the area "under ditch" is as reported in the forgoing, the value for taxation purposes will not be less than $10 per acre, or a total valuation of $136,610,000, while that actually cultivated may be placed by a low valuation at $15 per acre, or a total of $125,270,000. And these being considered as assessor's figures may fairly be doubled. The cost of reclamation will certainly not exceed, all told, more than $7 per acre, or a total of $95,627,000. Indeed it is more probable that $50,000,000 will cover the actual cost of reclaiming the area at present irrigated.

The Senate committee made the following argument on the utility of irrigation.

The amount of land that may be brought under cultivation in the arid region by irrigation is variously estimated at from 75,000,000 to 150,000,000 acres. It is safe to predict that at least 100,000,000 acres will be ultimately brought under cultivation by irrigation, and that, too, by the water in sight which, when properly utilized, will readily reclaim at least 10 per cent. of the whole arid area. It is worthy of remark that land cultivated by irrigation is much more productive than land where the rainfall is sufficient to produce crops. The certainty of crops every year in an irrigated country where the water supply is sufficient is a most important consideration. Besides, in nearly every part of the arid region more than one crop can be produced each year from the same land, and a good crop is always certain with a constant water supply. Irrigation requires unremitting attention and high cultivation and with such attention and cultivation it is calculated that in any given period of ten years irrigated land will produce from three to five times as much as land cultivated by rainfall.

The question for consideration is: What action should be taken by the Government to enable the people to reclaim these desert lands? The reclamation must be initiated and executed by the people, and not by their Government. In India, and, in fact, in all countries under monarchial or despotic rule, the work of irrigation has been carried on under Government control and largely with Government money. The Government of British India has already expended several hundred millions of dollars in constructing irrigation works, and is continuing such expenditures on a most magnificent scale. The reports show that the investment has been profitable to the Government and of the greatest possible advantage to the people.

But there is no necessity for the United States to engage in such expenditures. If the opportunity is furnished to the people of this country they will reclaim these desert lands so far as reclamation is necessary. The use of industrial co-operation in developing the mineral resources of the far West demonstrates the capacity of the people for great undertakings, which in other countries require vast expenditures of accumulated capital.

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LEGAL CONDITIONS OF IRRIGATION.

THE CONSTITUTIONAL PROVISIONS AND LAWS OF THE SEVERAL STATES AND TERRITORIES WITHIN THE ARID REGION IN RELATION TO WATER RIGHTS, PUBLIC CONTROL, AND BENEFICIAL USES, WITH A LIST OF CASES AND DECISIONS.

PART V.

Those who desire to understand the progress of irrigation will do well to carefully examine the constitutional provisions adopted by the several States which are in whole or in part within the area of aridity. Until within a few years past very little attention has been paid to safeguards over natural property, such as water, and through the public control of which, for beneficial uses, can the security of industry alone be achieved.

California, Nevada, and Oregon, the three States first formed west of the eastern lines of industrial moisture, have made no constitutional provision affecting the public character of this use. In their statutes and before their courts the isues involved have constantly been acted upon. There has grown up or evolved out of the necessities of the people and the exigencies of the communities interested a great body of law, custom, regulation, and judicial interpretation. These start in general from the principle of prior appropriation as wrought out by the earlier miners, and embodied in Federal law, and then by the States and Territories, being steadily sustained by the courts, with a few exceptions, as the common law of an arid region such as ours. The development of the beneficial use of water has of course modified the practice of prior appropriations to a first or prior pro rata share of the natural waters, when taken from bed or source for industrial purposes.

The people of Colorado were the first to perceive both the just theory and the exacting conditions embodied in the public nature of water. Its constitution, therefore, becomes a starting point, as framed and adopted in 1875–'76. The sections relating to water rights and obligations are as follows:

CONSTITUTION OF CALIFORNIA.

WATER AND WATER RIGHTS.

SECTION 1. The use of all water now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution, is hereby declared to be a public use, and subject to the regulation and control of the State, in the manner to be prescribed by law: *Provided*, That the rates or compensation to be collected by any person, company, or corporation in this State for the use of water supplied to any city and county, or city or town, or the inhabitants thereof, shall be fixed annually by the board of supervisors, or city or town, by ordinance or otherwise, in the manner that other ordinances or legislative acts or resolutions are passed by such body, and shall continue in force for one year and no longer. Such ordinances or resolutions shall be passed in the month of February of each year, and take effect on the first day of July thereafter. Any board or body failing to pass the necessary ordinances or resolutions fixing water rates, where necessary, within such time, shall be subject to peremptory process to compel action at the suit of any party interested, and shall be liable to such further processes and penalties as the legislature may prescribe. Any person, company, or corporation collecting water rates, in any city and county, or city or town in this State, otherwise than as so established, shall forfeit the franchises and water-works of such person, company, or corporation, to the city and county, or city or town, where the same are collected for the public use.

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SECTION 2. The right to collect rates or compensation for the use of water supplied to any county, city and county, or town, or the inhabitants thereof, is a franchise, and cannot be exercised except by authority of and in the manner prescribed by law.

CONSTITUTION OF COLORADO.

WATER RIGHTS—PRIORITIES AND RIGHTS THEREUNDER.

ARTICLE XVI. SEC. 5. The water of every natural stream not heretofore appropriated, within the State of Colorado, is hereby declared to be the property of the public, and is dedicated to the use of the people of the State, subject to appropriation as hereinafter provided.

SEC. 6. The right to divert unappropriated waters of every natural stream for beneficial uses shall never be denied. Priority of appropriation shall give the better right, as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes.

ART. II. SEC. 14. Private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and except for reservoirs, drains, flumes, or ditches, on or across the lands of others, for agricultural, mining, milling, domestic, or sanitary purposes.

ART. II. SEC. 15. Private property shall not be taken or damaged for public or private use without just compensation. Such compensation shall be ascertained by a board of commissioners of not less than three freeholders, or by a jury when required by the owner of the property, in such manner as may be prescribed by law, and until the same shall be paid to the owner, or into court for the owner, the property shall not be needlessly disturbed, or the proprietary rights of the owner therein invested [divested]; and whenever an attempt is made to take private property for a use alleged to be public, the question whether the contemplated use be really public shall be a judicial question, and determined as such without regard to any legislative assertion that the use is public.

ART. XVI. SEC. 7. All persons and corporations shall have the right of way across public, private, and corporate lands for the construction of ditches, canals, and flumes, for the purpose of conveying water for domestic purposes, for the irrigation of agricultural lands, and for mining and manufacturing purposes, and for drainage, upon payment of just compensation.

ART. XVI. SEC. 8. The general assembly shall provide by law that the board of county commissioners in their respective counties shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for use of water whether furnished by individuals or corporations.

ART. X. SEC. 3. Ditches, canals, and flumes owned and used by individuals or corporations for irrigating lands owned by such individuals or corporations, or the individual members thereof, shall not be separately taxed so long as they shall be owned and used exclusively for such purposes.

CONSTITUTION OF IDAHO.*

BILL OF RIGHTS.

ARTICLE I. SEC. 14. The necessary use of lands for the construction of reservoirs, or storage basins, for the purposes of irrigation, or for rights of way for the construction of canals, ditches, flumes, or pipes, to convey water to the place of use, for any useful, beneficial, or necessary purpose, or for drainage, or for the drainage of mines, or the working thereof, by means of roads, railroads, tramways, cuts, tunnels, shafts, hoisting works, dumps, or other necessary means to their complete development, or any other use necessary to the complete development of the material resources of the State, or the preservation of the health of its inhabitants, is hereby declared to be a public use, and subject to the regulation and control of the State.

Private property may be taken for a public use, but not until a just compensation, to be ascertained in a manner prescribed by law, shall be paid therefor.

WATER RIGHTS.

ART. XV. SEC. 1. The use of all waters now appropriated, or that may hereafter be appropriated for sale, rental, or distribution; also of all water originally appropriated for private use, but which after such appropriation has heretofore been, or may

* These provisions and those of Montana, North Dakota, Washington and Wyoming, were all adopted in 1889.

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hereafter be sold, rented, or distributed, is hereby declared to be a public use, and subject to the regulation and control of the State in the manner prescribed by law.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city, or town, or water district, or the inhabitants thereof, is a franchise, and can not be exercised except by authority of and in the manner prescribed by law.

SEC. 3. The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall (subject to such limitations as may be prescribed by law) have the preference over those claiming for any other purpose; and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes. And in any organized mining district those using the water for mining purposes or milling purposes connected with mining, shall have preference over those using the same for manufacturing or agricultural purposes. But the usage by such subsequent appropriators shall be subject to such provisions of law regulating the taking of private property for public and private use, as referred to in section fourteen of Article I, of this constitution.

SEC. 4. Whenever any waters have been, or shall be, appropriated or used for agricultural purposes, under a sale, rental, or distribution thereof, such sale, rental, or distribution shall be deemed an exclusive dedication to such use; and whenever such waters so dedicated shall have once been sold, rented, or distributed to any person who has settled upon or improved land for agricultural purposes with the view of receiving the benefit of such water under such dedication, such person, his heirs, executors, administrators, successors, or assigns, shall not thereafter, without his consent, be deprived of the annual use of the same, when needed for domestic purposes, or to irrigate the land so settled upon or improved, upon payment therefor, and compliance with such equitable terms and conditions as to the quantity used and times of use, as may be prescribed by law.

SEC. 5. Whenever more than one person has settled upon or improved land with the view of receiving water for agricultural purposes under a sale, rental, or distribution thereof, as in the last preceding section of this article provided, as among such persons priority in time shall give superiority of right to the use of such water in the numerical order of such settlements or improvements; but whenever the supply of such water shall not be sufficient to meet the demands of all those desiring to use the same, such priority of right shall be subject to such reasonable limitations as to the quantity of water used and times of use as the legislature, having due regard both to such priority of right and the necessities of those subsequent in time of settlement or improvement, may by law prescribe.

SEC. 6. The legislature shall provide by law the manner in which reasonable maximum rates may be established to be charged for the use of water sold, rented, or distributed for any useful or beneficial purpose.

CONSTITUTION OF MONTANA.

WATER RIGHTS.

SECTION 1. The use of all waters now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution; also, of all water originally appropriated for private use, but which, after such appropriation has heretofore been, or may hereafter be, sold, rented, or distributed, is hereby declared to be a public use, and subject to the regulation and control of the State in the manner prescribed by law.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city, or town, or water district, or the inhabitants thereof, is a franchise, and can not be exercised except by authority of and in the manner prescribed by law.

SEC. 3. The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same those using the water for domestic purposes shall (subject to such limitations as may be prescribed by law) have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes.

SEC. 4. All persons and corporations shall have the right of way across public, private, and corporate lands for the construction and maintenance of canals, ditches, flumes, or pipes for the purpose of conveying water to the place of use, for any use-

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ful or beneficial purpose, and for drainage upon paying therefore a just compensation in the manner prescribed by law.

SEC. 5. Whenever any waters have been, or shall be, appropriated or used for agricultural purposes under a sale, rental, or distribution thereof, such sale, rental, or distribution shall be deemed an exclusive dedication to such use; and whenever such waters so dedicated shall have ever been sold, rented, or distributed to any person who has settled upon or improved land for agricultural purposes with a view of receiving the benefit of such water under such dedication, such person, his heirs, executors, administrators, successors, or assigns shall not thereafter without his consent be deprived of the annual use of the same when needed for domestic purposes, or to irrigate the land so settled upon or improved, upon payment therefor and compliance with such equitable terms and conditions as to the quantity used and times of use as may be prescribed by law.

SEC. 6. Whenever more than one person has settled upon or improved land with the view of receiving water for agricultural purposes under a sale, rental, or distribution thereof, as in the last preceding section of this article provided, as among such persons priority in time shall give superiority of right to the use of such water in the numerical order of such settlements or improvements; but whenever the supply of such water shall not be sufficient to meet the demands of all those desiring to use the same, such priority of right shall be subject to such reasonable limitations as to the quantity of water used and times of use as the legislative assembly, having due regard both to such priority of right and the necessities of those subsequent in time of settlement or improvement, may by law prescribe.

SEC. 7. The legislative assembly shall provide by law the manner in which reasonable maximum rates may be established to be charged for the use of water sold, rented, or distributed for any useful or beneficial purpose.

CONSTITUTION OF NEW MEXICO.

[Proposed article.]

MINING AND WATER RIGHTS.

ART. XIV. SEC. 5. Whenever by priority of possession rights to the use of water for mining, agriculture, manufacturing, or other purposes have vested and accrued the possessors and owners of such vested rights shall be maintained and protected in the same, and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed subject to the restrictions of this constitution as to taking property for public or private use.

CONSTITUTION OF NORTH DAKOTA.

ART. XVII. SEC. 210. All flowing streams and natural water-courses shall forever remain the property of the State for mining, irrigating, and manufacturing purposes.

CONSTITUTION OF WASHINGTON.

WATER AND WATER RIGHTS.

ART. XXI. SEC. 1. The use of the waters of this State for irrigation, mining, and manufacturing purposes shall be deemed a public use.

CONSTITUTION OF WYOMING.

[Proposed article.]

DECLARATION OF RIGHTS.

ART. I. SEC. 31. Water being essential to industrial prosperity, of limited amount, and easy of diversion from its natural channels, its control must be in the State, which in providing for its use shall equally guard all the various interests involved.

SEC. 32. Private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and for reservoirs, drains, flumes, or ditches on or across the lands of others for agricultural, mining, milling, domestic, or sanitary purposes, nor in any case without due compensation.

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IRRIGATION AND WATER RIGHTS.

ART. VIII. SEC. 1. The water of all natural streams, springs, lakes, or other collection of still water, within the boundaries of the State, are hereby declared to be the property of the State.

SEC. 2. There shall be constituted a board of control, to be composed of the State engineer and superintendents of the water divisions, which shall, under such regulations as may be prescribed by law, have the supervision of the waters of the State and of their appropriation, distribution, and diversion, and of the various officers connected therewith, its decisions to be subject to review by the courts of the State.

SEC. 3. Priority of application for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interests.

SEC. 4. The legislature shall by law divide the State into four water divisions, and provide for the appointment of superintendents thereof.

SEC. 5. There shall be a State engineer, who shall be appointed by the governor of the State and confirmed by the senate; he shall hold his office for the term of six years, or until his successor shall have been appointed and shall have qualified. He shall be president of the board of control, and shall have general supervision of the water of the State and of the officers connected with its distribution. No person shall be appointed to this position who has not such theoretical knowledge and such practical experience and skill as shall fit him for the position.

CORPORATIONS.

ART. X. SEC. 1. The legislature shall provide for the organization of corporations by general law. All laws relating to corporations may be altered, amended, or repealed by the legislature at any time when necessary for the public good and general welfare, and all corporations doing business in this State may as to such business be regulated, limited, or restrained by law not in conflict with the Constitution of the United States.

SEC. 2. All powers and franchises of corporations are derived from the people, and are granted by their agent, the Government, for the public good and general welfare, and the right and duty of the State to control and regulate them for these purposes is hereby declared. The power, rights, and privileges of any and all corporations may be forfeited by willful neglect or abuse thereof. The police power of the State is supreme over all corporations as well as individuals.

SEC. 3. All existing charters, franchises, special or exclusive privileges under which an actual and bona fine organization shall not have taken place for the purpose for which formed and which shall not have been maintained in good faith to the time of the adoption of this constitution, shall thereafter have no validity.

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LAWS RELATING TO IRRIGATION, WATER CONSERVATION AND DISTRIBUTION.

ARIZONA IRRIGATION LAWS.

WATERS AND WATER RIGHTS.

CHAPTER 1.—*Riparian rights.*

3198. (Sec. 1.) The common-law doctrine of riparian rights shall not obtain or be of any force or effect in this Territory.

CHAPTER 2.—*Irrigating canals and acequias.*

3199. (Sec. 1.) All rivers, creeks, and streams of running water in the Territory of Arizona are hereby declared public and applicable to the purposes of irrigating and mining, as hereinafter provided.

3200. (Sec. 2.) All rights in acequias, or irrigating canals, heretofore established shall not be disturbed, nor shall the course of such acequias be changed without the consent of the proprietors of such established rights.

3201. (Sec. 3.) All the inhabitants of this Territory who own or possess arable and irrigable lands shall have the right to construct public or private acequias, and obtain the necessary water for the same from any convenient river, creek, or stream of running water.

3202. (Sec. 4.) Whenever such public or private acequias shall necessarily run through the lands of any private individuals not benefited by said acequias, the damages resulting such private individuals, on the application of the party interested, shall be assessed by the probate judge of the proper county in a summary manner.

3203. (Sec. 5.) No inhabitant of this Territory shall have the right to erect any dam, or build a mill, or place any machinery, or open any sluice, or make any dyke, except such as are used for mining purposes or the reduction of metals, as provided for in sections 6 and 7 of this chapter, that may impede or obstruct the irrigation of any lands or fields, as the right to irrigate the fields and arable lands shall be preferable to all others; and the justices of the peace of the respective precincts shall hear and determine the question relative to all such obstructions in a summary manner, and cause the removal of the same by order directed to the constable of the precincts or sheriff of the county, who shall proceed to execute the same without delay.

3204. (Sec. 6.) Where reduction works or other mining apparatus shall be placed upon lands previously held for agricultural purposes, or persons so holding such lands shall be entitled to remuneration from person or persons erecting or owning said reduction works or mining apparatus, the amount of remuneration shall be adjudged by three or five disinterested persons, or by the probate judge, as the parties interested shall agree; and in case such agreement can not be made, then the party injured may bring suit for damages.

3205. (Sec. 7.) When any ditch or acequia shall be taken out for agricultural purposes, the person or persons so taking out such ditch or acequia shall have the exclusive right to the water, or so much thereof as shall be necessary for said purposes; and if at any time the waters so required shall be taken for mining operations, the person or persons owning said water shall be entitled to damages to be assessed in the manner provided in section 6 of this chapter.

3206. (Sec. 8.) All by-paths or footpaths across any cultivated fields are prohibited, under penalty of a fine not to exceed $10 for the public acequia, to be assessed in a summary manner by the justice of the peace of the precinct; and if the person so offending shall not have wherewith to pay the fine, he shall be adjudged and sentenced to ten days on the public acequia.

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3207. (Sec. 9.) All owners of arable and irrigable land bordering on, or irrigable by, any public acequia, shall labor on such public acequia, whether such owners or proprietors cultivate the land or not.

3208. (Sec. 10.) All persons interested in a public acequia, whether owners or lessees of land, shall labor thereon in proportion to the amount of land owned or held by them, and which may be irrigated or subject to irrigation.

3209. (Sec. 11.) It being impracticable to properly inclose the fields in this Territory, all animals shall be kept under a shepherd so that no injury may result to the fields; and if any damage should result, it shall be paid by the owners of the animals causing the same, to be assessed by the justice of the peace of the precinct in a summary manner, and paid to the person or persons whose fields may have been damaged.

3210. (Sec. 12.) In case a community or people desire to construct an acequia in any part of this Territory, and the persons desiring to construct the same are the owners or proprietors of the land upon which they design constructing the said acequia, no one shall be bound to pay damages for such land, as all persons interested in the construction of the said acequia are to be benefited thereby.

3211. (Sec. 13.) Immediately after the publication of this chapter, it shall be the duty of the several justices of the peace in this Territory to call together, in their respective precincts, all the owners and proprietors of land, irrigated by any public acequia, for the purpose of electing one or more overseers for said acequia for the corresponding year.

3212. (Sec. 14.) The manner of conducting such elections, and the number of overseers, shall be regulated by the justices of the peace of their respective precincts; and the only persons entitled to vote at said elections shall be the owners and proprietors of lands irrigated by said acequias.

3213. (Sec. 15.) The pay and perquisites of said overseer shall be determined by a majority of the owners and proprietors of the lands irrigated by said acequias, and paid by them.

3214. (Sec. 16.) It shall be the duty of the overseers to superintend the opening, excavations, and repairs of said acequias; to apportion the number of laborers furnished by the owners, and proprietors; to regulate them according to the quantity of land to be irrigated by each one from said acequia, to distribute and apportion the water in proportion to the quantity to which each one is entitled according to the land cultivated by him; and, in making such apportionment, he shall take into consideration the nature of the seed sown or planted, the crops and plants cultivated, and to conduct and carry on such distribution with justice and impartiality.

3215. (Sec. 17.) During years when a scarcity of water shall exist, owners of fields shall have precedence of the water for irrigation, according to the dates of their respective titles or their occupation of the lands, either by themselves or their grantors. The oldest titles shall have precedence always.

3216. (Sec. 18.) It shall be the duty of each of the owners and proprietors to furnish the number of laborers required by the overseer, at the time and place he may designate, for the purposes mentioned in the foregoing section, and for the time he may deem necessary.

3217. (Sec. 19.) If any overseer of any public acequia, after having undertaken to serve as such, shall willfully neglect or refuse to fulfill the duties required of him by this chapter, or conduct himself with impropriety or injustice in his office as overseer; or take any bribe in money, property, or otherwise, as an inducement to act improperly; or neglect the duties of his office, he shall be fined for each of said offenses in a sum not exceeding $100 nor less than $50, to be recovered before any justice of the peace of the county—one-half of which shall be paid to the county and the other half to the person bringing suit for the same—the said suit to be brought in the name of the Territory of Arizona; and said overseer, on being convicted a second time, shall be removed from his office by the justice of the peace of the precinct, and shall take such pay and perquisites as may be due him for services rendered.

3218. (Sec. 20.) Upon such removal, the justice of the peace shall order a new election to fill the vacancy thereby occasioned, which shall be conducted in the manner prescribed in the thirteenth and fourteenth sections of this chapter.

3219. (Sec. 21.) If any owner or proprietor of land irrigated by such acequia shall neglect or refuse to furnish the number of laborers required by the overseer, as required in the eighteenth section of this chapter after having been duly notified by the overseer, he shall be fined for each offense in a sum not exceeding $10 for the benefit of said acequia, which shall be recovered by the overseer before any justice of the peace in the county, and in such cases the overseer shall be a competent witness to prove the offense or any fact that may serve to constitute the same.

3220. (Sec. 22.) If any person shall in any manner interfere with, impede, or obstruct any of said acequias, or use the water from it without the consent of the overseer, except as provided in section 7 of this chapter during the time of cultivation, he shall pay for each offense a sum not exceeding $10, which shall be recoverable in

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the manner prescribed in the foregoing section for the benefit of said acequia; and he shall further pay all damages that may have accrued to the injured parties, and, if such person have not wherewith to pay said fine and damages, he shall be sentenced to fifteen days' labor on said public acequia.

3221. (Sec. 23.) All fines and forfeitures received for the use and benefit of any public acequia shall be applied by the overseers to the improvements, excavations, and repairs which may be necessary on said acequia, and for the construction of bridges where they may be crossed by any public street or road.

3222. (Sec. 24.) In all cases of conviction under this chapter an appeal shall be allowed to the probate court, which appeal shall be taken and conducted as all other appeals from the decisions of the justices of the peace.

3223. (Sec. 25.) The regulations of acequias, which have been worked according to the laws and customs of Sonora and the usages of the people of Arizona, shall remain as they were made and used up to this day; and the provisions of this chapter shall be enforced and observed from the day of its publication.

3224. (Sec. 26.) All plants and trees of any description growing on the banks of any acequia shall belong to the owners of the land through which said acequia may run.

3225. (Sec. 27.) Any person owning lands which may include a spring or stream of running water, or owning lands upon a river where there is not population sufficient to form a public acequia, may construct a private acequia for his own uses, subject to his own regulations, provided it does not interfere with the rights of others.

3226. (Sec. 28.) All laws conflicting with the provisions of this chapter are hereby repealed.

[NOTE.—The foregoing chapter is compiled and taken from the Compiled Laws, Chapter LV, page 528. There was no legislation upon the subject by the fourteenth legislature (1887), and this chapter remained unchanged.]

CHAPTER 3—*Ditch Crossings.*

3227. (Sec. 1.) Any person, corporation or company, owning or using any ditch or canal constructed for the purpose of conveying water, shall construct and maintain suitable crossings wherever said ditch or canal crosses any public highway, or usually traveled road of this Territory; said crossing shall be maintained as follows:

From the bottom of the ditch in the roadway there shall be a uniform rise of not more than 1 foot in 3 to the top of the embankment; either side the ditch shall be graveled or macadamized with stone to a depth of not less than 10 inches from the top of one embankment to the other, and the macadamized or paved road across any of said ditches shall not be less than 14 feet wide; provided, that any person or persons, corporation or company may at any of said crossings construct and build a good and substantial bridge to be approved of by the road overseers of the district.

3228. (Sec. 2.) The road overseer of each of the districts in the several counties in this Territory shall have supervision of said crossings, and it shall be his duty to see that the several ditch crossings in his district are constructed and maintained as provided in the preceding section.

3229. (Sec. 3.) For neglect or refusal of any person or persons, corporation or company, whose duty it shall be to construct or maintain such crossings as provided for in section 1, for the period of ten days after being notified in writing by the road overseer of the district in which any such crossing needs construction or repair that such construction or repair is required, such person, corporation or company shall be guilty of a misdemeanor, and upon conviction thereof before a justice of the peace of any such precincts, shall be fined not less than $10 or more than $100 for the first offense; and of not less than $25 nor more than $250, and the costs of prosecution, for each subsequent offense; provided, that whenever such highway or road is constructed, after the construction of such ditch or canal, it shall be the duty of the road overseer of the district to construct and maintain such crossing at the expense of the road fund of the district, and if the same be at any time insufficient, the same shall be paid out of the general fund in the county treasury, to be chargeable to and thereafter collected from such road fund.

3230. (Sec. 4.) All funds collected under the provisions of this act shall be paid into the road fund of the district, wherever such crossings are required.

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THE IRRIGATION LAWS OF CALIFORNIA.

WRIGHT IRRIGATION BILL AND AMENDMENTS, 1889.

AN ACT to provide for the organization and government of irrigation districts and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes.

SECTION 1. Whenever fifty or a majority of freeholders owning lands susceptible of one mode of irrigation from a common source, and by the same system of works, desire to provide for the irrigation of the same, they may propose the organization of an irrigation district under the provisions of this act, and when so organized such district shall have the powers conferred or that may hereafter be conferred by law upon such irrigation district.

SEC. 2. A petition shall first be presented to the board of supervisors of the county in which the lands or the greatest portion thereof is situated, signed by the required number of freeholders of such proposed district, which petition shall set forth and particularly describe the proposed boundaries of such district, and shall pray that the same may be organized under the provisions of this act. The petitioners must accompany the petition with a good and sufficient bond, to be approved by the said board of supervisors, in double the amount of the probable cost of organizing such district, conditioned that the bondsmen will pay all said cost in case said organization shall not be effected. Such petition shall be presented at a regular meeting of the said board, and shall be published for at least two weeks before the time at which the same is to be presented, in some newspaper printed and published in the county where said petition is presented, together with a notice stating the time of the meeting at which the same will be presented. When such petition is presented, the said board of supervisors shall hear the same, and may adjourn such hearing from time to time, not exceeding four weeks in all; and on the final hearing may make such changes in the proposed boundaries as they may find to be proper, and shall establish and define such boundaries: *Provided*, That said board shall not modify said boundaries so as to except from the operation of this act any territory within the boundaries of the district proposed by said petitioners, which is susceptible of irrigation by the same system of works applicable to the other lands in such proposed district, nor shall any lands which will not, in the judgment of the said board, be benefited by irrigation by said system be included within such district: *Provided*, That any person whose lands are susceptible of irrigation from the same source shall, upon application of the owner to said board, be entitled to have such lands included in said district. Said board shall also make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered first, second, third, fourth, and fifth, and one director shall be elected from each district. Said board of supervisors shall then give notice of an election to be held in such proposed district, for the purpose of determining whether or not the same shall be organized under the provisions of this act. Such notice shall describe boundaries so established, and shall designate a name for such proposed district, and said notice shall be published for at least three weeks prior to such election in a newspaper published within said county; and if any portion of such proposed district lie within another county or counties, then said notice shall be published in a newspaper published within each of said counties. Such notice shall require the electors to cast ballots which shall contain the words, "Irrigation district—Yes," or, "Irrigation district—No," or words equivalent thereto; and also the names of persons to be voted for to fill the various elective offices hereinafter prescribed. No person shall be entitled to vote at any election held under the provisions of this act unless he shall possess all the qualifications required of electors under the general election laws of this State.

SEC. 3. Such election shall be conducted in accordance with the general election laws of the State, provided that no particular form of ballot shall be required. The said board of supervisors shall meet on the second Monday next succeeding such election, and proceed to canvass the votes thereat; and if upon such canvass it appear that at least two-thirds of all the votes cast are "Irrigation district—Yes," the said board shall, by an order entered on their minutes, declare such territory duly organized as an irrigation district, under the name and style theretofore designated, and shall declare the persons receiving, respectively, the highest number of votes for such several offices to be duly elected to such offices. Said board shall cause a copy of such order, duly certified, to be immediately filed for record in the office of the county recorder of each county in which any portion of such lands are situated, and must also immediately forward a copy thereof to the clerk of the board of supervisors of each of the counties in which any portion of the district may lie; and no board of supervisors of any county, including any portion of such district, shall, after the date of the organization of such district, allow another district to be formed including any of

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the lands in such district, without the consent of the board of directors thereof; and from and after the date of such filing, the organization of such district shall be complete, and the officers thereof shall be entitled to enter immediately upon the duties of their respective offices, upon qualifying in accordance with law, and shall hold such offices, respectively, until their successors are elected and qualified. For the purposes of the election above provided for, the said board of supervisors must establish a convenient number of election precincts in said proposed district, and define the boundaries thereof, which said precincts may thereafter be changed by the board of directors of such district.

SEC. 4. An election shall be held in such district on the first Wednesday in April, eighteen hundred and eighty-eight, and on the first Wednesday in April in each second year thereafter, at which an assessor, a collector, and a treasurer, and a board of five directors for the district shall be elected. The person receiving the highest number of votes for any office to be filled at such election is elected thereto. Within ten days after receiving their certificates of election, hereinafter provided for, said officers shall take and subscribe the official oath and file the same in the office of the board of directors. The assessors shall execute an official bond in the sum of ten thousand dollars, and the collector an official bond in the sum of twenty thousand dollars, and the district treasurer an official bond in the sum of fifty thousand dollars; each of said bonds to be approved by the board of directors; and each member of said board of directors shall execute an official bond in the sum of twenty-five thousand dollars, which said bonds shall be approved by the judge of the superior court of said county where such organization was effected and shall be recorded in the office of the county recorder thereof, and filed with the secretary of said board. All official bonds herein provided for shall be in form prescribed by law for the official bonds of county officers.

SEC. 5. Fifteen days before any election held under this act, subsequent to the organization of any district, the secretary of the board of directors shall cause notice to be posted in three public places in each election precinct of the time and place of holding the election, and shall also post a general notice of the same in the office of said board, which shall be established and kept at some fixed place to be determined by said board, specifying the polling places of each precinct. Prior to the time for posting the notices, the board must appoint for each precinct, from the electors thereof, one inspector and two judges, who shall constitute a board of election for such precinct. If the board fail to appoint a board of election, or the members appointed do not attend at the opening of the polls on the morning of election, the electors of the precinct present at that hour may appoint the board, or supply the place of an absent member thereof. The board of directors must, in its order appointing the board of election, designate the house or place within the precinct where the election must be held.

SEC. 6. The inspector is chairman of the election board, and may:

First. Administer all oaths required in the progress of an election.

Second. Appoint judges and clerks, if during the progress of the election any judge or clerk cease to act. Any member of the board of election, or any clerk thereof, may administer and certify oaths required to be administered during the progress of an election. The board of election for each precinct must, before opening the polls, appoint two persons to act as clerks of the election. Before opening the polls, each member of the board and each clerk must take and subscribe an oath to faithfully perform the duties imposed upon them by law. Any elector of the precinct may administer and certify such oath. The polls must be opened one hour after sunrise on the morning of the election, and be kept open until sunset, when the same must be closed. The provisions of the Political Code concerning the form of ballots to be used shall not apply to elections held under this act.

SEC. 7. Voting may commence as soon as the polls are opened, and may be continued during all the time the polls remain opened, and shall be conducted as nearly as practicable in accordance with the provisions of chapter nine of title two of part three of the Political Code of this State. As soon as the polls are closed, the judges shall open the ballot-box and commence counting the votes; and in no case shall the ballot-box be removed from the room in which the election is held until all the ballots have been counted. The counting of ballots shall in all cases be public. The ballots shall be taken out, one by one, by the inspector or one of the judges, who shall open them and read aloud the names of each person contained therein, and the office for which every such person is voted for. Each clerk shall write down each office to be filled, and the name of each person voted for for such office, and shall keep the number of votes by tallies as they are read aloud by the inspector or judge. The counting of votes shall be continued without adjournment until all have been counted.

SEC. 8. As soon as all the votes are read off and counted a certificate shall be drawn up on each of the papers containining the poll list and tallies, or attached thereto, stating the number of votes each one voted for has received, and designating the office to fill which he was voted for, which number shall be written in figures and in words at full length. Each certificate shall be signed by the clerk, judge, and the

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inspector. One of said certificates, with the poll list and tally paper to which it is attached, shall be retained by the inspector, and preserved by him at least six months. The ballots shall be strung upon a cord or thread by the inspector, during the counting thereof, in the order in which they are entered upon the tally list by the clerks; and said ballots, together with the other of said certificates, with the poll list and tally paper to which it is attached, shall be sealed by the inspector in the presence of the judges and clerks, and indorsed "Election returns of (naming the precinct) precinct," and be directed to the secretary of the board of directors, and shall be immediately delivered by the inspector, or by some other safe and responsible carrier designated by said inspector, to said secretary, and the ballots shall be kept unopened for at least six months, and if any person be of the opinion that the vote of any precinct has not been correctly counted, he may appear on the day appointed for the board of directors to open and canvass the returns, and demand a recount of the vote of the precinct that is so claimed to have been incorrectly counted.

SEC. 9. No list, tally paper, or certificate returned from any election shall be set aside or rejected for want of form if it can be satisfactorily understood. The board of directors must meet at its usual place of meeting on the first Monday after each election to canvass the returns. If at the time of meeting the returns from each precinct in the district in which the polls were opened have been received, the board of directors must then and there proceed to canvass the returns; but if all the returns have not been received the canvass must be postponed from day to day until all the returns have been received, or until six postponements have been had. The canvass must be made in public and by opening the returns and estimating the vote of the district for each person voted for and declaring the result thereof.

SEC. 10. The secretary of the board of directors must, as soon as the result is declared, enter in the records of such board a statement of such result, which statement must show:

First. The whole number of votes cast in the district.

Second. The names of the persons voted for.

Third. The office to fill which each person was voted for.

Fourth. The number of votes given in each precinct to each of such persons.

Fifth. The number of votes given in the district to each of such persons.

The board of directors must declare elected the person having the highest number of votes given for each office to be filled by the votes of the district. The secretary must immediately make out and deliver to such person a certificate of election signed by him and authenticated with the seal of the board. In case of a vacancy in the office of assessor, tax collector, or treasurer, the vacancy shall be filled by appointment by the board of directors. In case of a vacancy in the office of member of the board of directors, the vacancy shall be filled by appointment by the board of supervisors of the county where the office of such board is situated. An officer appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 11. On the first Wednesday in May next following their election the board of directors shall meet and organize as a board, elect a president from their number, and appoint a secretary. The board shall have the power, and it shall be their duty, to manage and conduct the business and affairs of the district, make and execute all necessary contracts, employ and appoint such agents, officers, and employés as may be required, and prescribe their duties, establish equitable by-laws, rules, and regulations for the distribution and use of water among the owners of said lands, and generally to perform all such acts as shall be necessary to fully carry out the purposes of this act. The said by-laws, rules, and regulations must be printed in convenient form for distribution in the district. And it is hereby expressly provided that all waters distributed for irrigation purposes shall be apportioned ratably to each land owner upon the basis of the ratio which the last assessment of such owner for district purposes within said district bears to the whole sum assessed upon the district: *Provided*, That any land owner may assign the right to the whole or any portion of the waters so apportioned to him.

SEC. 12. The board of directors shall hold a regular monthly meeting in their office on the first Tuesday in every month, and such special meetings as may be required for the proper transaction of business: *Provided*, That all special meetings must be ordered by a majority of the board; the order must be entered of record, and five days' notice thereof must, by the secretary, be given to each membe not joining in the order. The order must specify the business to be transacted, and none other than that specified must be transacted at such special meeting. All meetings of the board must be public, and three members shall constitute a quorum for the transaction of business, but on all questions requiring a vote there shall be a concurrence of at least three members of said board. All records of the board shall be open to the inspection of any elector during business hours. The board and its agents and employés shall have the right to enter upon any land in the district to make surveys, and may locate the line for any canal or canals, and the necessary branches for the

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same, on any of said lands which may be deemed best for such location. Said board shall also have the right to acquire, either by purchase or condemnation, all lands and waters and other property necessary for the construction, use, supply, maintenance, repair, and improvement of said canal or canals and works, including canals and works constructed and being constructed by private owners, lands for reservoirs, for the storage of needful waters and all necessary appurtenances. In case of purchase the bonds of the district, hereinafter provided for, may be used at their par value in payment; and in case of condemnation the board shall proceed in the name of the district under the provisions of title seven of part three of the code of civil procedure. Said board may also construct the necessary dams, reservoirs, and works for the collection of water for said district, and do any and every lawful act necessary to be done, that sufficient water may be furnished to each land owner in said district for irrigation purposes. The use of all water required for the irrigation of the lands of any district formed under the provisions of this act, together with rights of way for canals and ditches, sites for reservoirs, and all other property required in fully carrying out the provisions of this act, is hereby declared to be a public use, subject to the regulation and control of the State in the manner prescribed by law.

SEC. 13. The legal title to all property acquired under the provisions of this act shall immediately and by operation of law vest in such irrigation district, and shall be held by such district in trust for and is hereby dedicated and set apart to the uses and purposes set forth in this act. And said board is hereby authorized and empowered to hold, use, acquire, manage, occupy, and possess said property as herein provided.

SEC. 14. The said board is hereby authorized and empowered to take conveyances or other assurances for all property acquired by it under the provisions of this act in the name of such irrigation district, to and for the uses and purposes herein expressed, and to institute and maintain any and all actions and proceedings, suits at law or in equity, necessary or proper in order to fully carry out the provisions of this act, or to enforce, maintain, protect, or preserve any and all rights, privileges, and immunities created by this act or acquired in pursuance thereof. And in all courts, actions, suits, or proceedings the said board may sue, appear, and defend, in person or by attorneys, and in the name of such irrigation district.

SEC. 15. For the purpose of constructing necessary irrigating canals and works and acquiring the necessary property and rights therefor, and otherwise carrying out the provisions of this act, the board of directors of any such district must, as soon after such district has been organized as may be practicable, estimate and determine the amount of money necessary to be raised, and shall immediately thereupon call a special election, at which shall be submitted to the electors of such district possessing the qualifications prescribed by this act the question whether or not the bonds of said district shall be issued in the amount so determined. Notice of such election must be given by posting notices in three public places in each election precinct in said district for at least twenty days, and also by publication of such notice in some newspaper published in the county where the office of the board of directors of such district is required to be kept once a week for at least three successive weeks. Such notices must specify the time of holding the election, the amount of bonds proposed to be issued, and said election must be held and the result thereof determined and declared in all respects as nearly as practicable in conformity with the provisions of this act governing the election of officers: *Provided*, That no informalities in conducting such an election shall invalidate the same if the election shall have been otherwise fairly conducted. At such election the ballots shall contain the words, "Bonds—Yes," or "Bonds—No," or words equivalent thereto. If a majority of the votes cast are "Bonds—Yes," the board of directors shall immediately cause bonds in said amount to be issued; said bonds shall be payable in gold coin of the United States in installments as follows, to wit: At the expiration of eleven years not less than five per cent. of said bonds; at the expiration of twelve years not less than six per cent.; at the expiration of thirteen years not less than seven per cent.; at the expiration of fourteen years not less than eight per cent.; at the expiration of fifteen years not less than nine per cent.; at the expiration of sixteen years not less than ten per cent.; at the expiration of seventeen years not less than eleven per cent.; at the expiration of eighteen years not less than thirteen per cent.; at the expiration of nineteen years not less than fifteen per cent.; and for the twentieth year a percentage sufficient to pay off said bonds; and shall bear interest at the rate of six per cent. per annum, payable semi-annually on the first day of January and July of each year. The principal and interest shall be payable at the office of the treasurer of the district. Said bonds shall be each of the denomination of not less than one hundred dollars, nor more than five hundred dollars, shall be negotiable in form, signed by the president and secretary, and the seal of the board of directors shall be affixed thereto. They shall be numbered consecutively as issued, and bear date at the time of their issue. Coupons for the interest shall be attached to each bond signed by the secretary. Said bonds shall express on their face that they were issued by authority of this act, stating its

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title and date of approval. The secretary shall keep a record of the bonds sold, their number, the date of sale, the price received, and the name of the purchaser.

SEC. 16. The board may sell said bonds from time to time in such quantities as may be necessary and most advantageous to raise money for the construction of said canals and works, the acquisition of said property and rights, and otherwise to fully carry out the objects and purposes of this act. Before making any sale the board shall, at a meeting, by resolution, declare its intention to sell a specified amount of the bonds and the day and hour and place of such sale, and shall cause such resolution to be entered in the minutes, and notice of the sale to be given by publication thereof at least twenty days in a daily newspaper published in each of the cities of San Francisco, Sacramento, and Los Angeles, and in any other newspaper, at their discretion. The notice shall state that sealed proposals will be received by the board at their office for the purchase of the bonds till the day and hour named in the resolution. At the time appointed the board shall open the proposals and award the purchase of the bonds to the highest responsible bidder, and may reject all bids; but said board shall in no event sell any of the said bonds for less than ninety per cent. of the face value thereof.

SEC. 17. Said bonds, and the interest thereon, shall be paid by revenue derived from an annual assessment upon the real property of the district; and all the real property in the district shall be and remain liable to be assessed for such payments as hereinafter provided.

SEC. 18. The assessor must, between the first Monday in March and the first Monday in June in each year, assess all real property in the district, to the persons who own, claim, have the possession or control thereof, at its full cash value. He must prepare an assessment book with appropriate headings, in which must be listed all such property within the district, in which must be specified in separate columns under the appropriate head:

First. The name of the person to whom the property is assessed. If the name is not known to the assessor, the property shall be assessed to "unknown owners."

Second. Land by township, range, section, or fractional section, and when such land is not a Congressional division or subdivision, by metes and bounds, or other description sufficient to identify it, giving an estimate of the number of acres, locality, and the improvements thereon.

Third. City and town lots, naming the city or town, and the number and block according to the system of numbering in such city or town, and the improvements thereon.

Fourth. The cash value of real estate, other than city or town lots.

Fifth. The cash value of improvements on such real estate.

Sixth. The cash value of city and town lots.

Seventh. The cash value of improvements on city and town lots.

Eighth. The cash value of improvements on real estate assessed to persons other than the owners of the real estate.

Ninth. The total value of all property assessed.

Tenth. The total value of all property after equalization by the board of directors.

Eleventh. Such other things as the board of directors may require.

SEC. 19. The board of directors must allow the assessor as many deputies, to be appointed by him, as will, in the judgment of the board, enable him to complete the assessment within the time herein prescribed. The board must fix the compensation of such deputies, which shall be paid out of the treasury of the district. The compensation must not exceed five dollars per day for each deputy, for the time actually engaged, nor must any allowance be made but for work done between the first Monday in March and the first Monday in August in each year.

SEC. 20. On or before the first Monday in August in each year the assessor must complete his assessment book, and deliver it to the secretary of the board, who must immediately give notice thereof, and of the time the board of directors, acting as a board of equalization, will meet to equalize assessments, by publication in a newspaper published in each of the counties comprising the district. The time fixed for the meeting shall not be less than twenty nor more than thirty days from the first publication of the notice; and in the meantime the assessment book must remain in the office of the secretary for the inspection of all persons interested.

SEC. 21. Upon the day specified in the notice required by the preceding section for the meeting, the board of directors, which is hereby constituted a board of equalization for that purpose, shall meet and continue in session from day to day, as long as may be necessary, not to exceed ten days, exclusive of Sundays, to hear and determine such objections to the valuation and assessment as may come before them; and the board may change the valuation as may be just. The secretary of the board shall be present during its sessions, and note all changes made in the valuation of property, and in the names of the persons whose property is assessed; and within ten days after the close of the session he shall have the total values, as finally equalized by the board, extended into columns and added.

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SEC. 22. The board of directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds; and at the expiration of ten years after the issuing of bonds by the board, must increase said assessment for the ensuing ten years, in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent.; for the twelfth year, six per cent.; for the thirteenth year, seven per cent.; for the fourteenth year, eight per cent.; for the fifteenth year, nine per cent.; for the sixteenth year, ten per cent.; for the seventeenth year, eleven per cent.; for the eighteenth year, thirteen per cent.; for the nineteenth year, fifteen per cent.; and for the twentieth year, a percentage sufficient to pay off said bonds. The secretary of the board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment on the property therein enumerated. When collected the assessment shall be paid into the district treasury, and shall constitute a special fund, to be called the "bond fund of [naming the district] irrigation district."

SEC. 23. The assessment upon real property is a lien against the property assessed from and after the first Monday in March for any year; and such lien is not removed until the assessments are paid or the property sold for the payment thereof.

SEC. 24. On or before the first day of November the secretary must deliver the assessment book to the collector of the district, who shall, within twenty days, publish a notice in a newspaper published in each of the counties comprising the district, if there be lands situated in more than one county in such district, that said assessments are due and payable and will become delinquent at 6 o'clock p. m. on the last Monday of December next thereafter; and that unless paid prior thereto five per cent. will be added to the amount thereof, and also the time and place at which payment of assessments may be made. The notice shall also specify a time and place within each election precinct of the district when and where the collector will attend to receive payment of assessments, and shall be published for fifteen days, and a printed copy of said notice shall be posted for the same time in some public place in each precinct. The collector must attend at the time and place specified in the notice to receive assessments, which must be paid in gold and silver coin. He must mark the date of payment of any assessment in the assessment book opposite the name of the person paying, and give a receipt to such person, specifying the amount of the assessment and the amount paid, with a description of the property assessed. On the thirty-first day of December of each year all unpaid assessments are delinquent, and thereafter the collector must collect thereon, for the use of the district, an addition of five per cent.

SEC. 25. On or before the first day of February, the collector must publish the delinquent list, which must contain the names of the persons and a description of the property delinquent, and the amount of the assessments and costs due opposite each name and description. He must append to and publish with the delinquent list a notice, that unless the assessments delinquent, together with cost and percentage, are paid, the real property upon which such assessments are a lien will be sold at public auction. The publication must be made once a week for three successive weeks in a newspaper published in each of the counties comprised in the district. The publication must designate the time and place of sale. The time of sale must not be less than twenty-one nor more than twenty-eight days from the first publication, and the place must be at some point designated by the collector.

SEC. 26. The collector must collect, in addition to the assessments due on the delinquent list and five per cent. added, fifty cents on each lot, piece, or tract of land separately assessed, one-half of which must go to the district and the other to the collector for preparing the list. On the day fixed for the sale, or some subsequent day to which he may have postponed it, of which he must give notice, the collector, between the hours of ten o'clock a. m. and three o'clock p. m., must commence the sale of the property advertised, commencing at the head of the list and continuing alphabetically, or in the numerical order of the lots or blocks, until completed. He may postpone the day of commencing the sales, or the sale, from day to day, but the sale must be completed within three weeks from the day first fixed.

SEC. 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the collector, prior to the sale, what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed, then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the collector for the duplicate certificate of sale, is the purchaser. If the purchaser does not pay the assessments and costs before ten o'clock a. m. the following day, the property, on next sale day, before the regular sale, must be resold for the assessments and costs. After receiving the amount of assessments and costs, the collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the name of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and the

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year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the collector, and one copy delivered to the purchaser, and the other filed in the office of the county recorder of the county in which the land sold is situated.

SEC. 28. The collector, before delivering any certificate, must in a book enter a description of the land sold, corresponding with the description in the certificate, the date of the sale, purchasers' names, and amount paid, regularly number the description on the margin of the book and put a corresponding number on each certificate. Such book must be open to public inspection, without fee, during office hours, when not in actual use. On filing the certificates with such county recorder the lien of the assessments vests with the purchaser, and is only divested by the payment to him, or to the collector for his use, of the purchase money and two per cent. per month from the day of sale until redemption.

SEC. 29. A redemption of the property sold may be made by the owner, or any party in interest, within twelve months from the date of purchase. Redemption must be made in gold or silver coin, as provided for the collection of State and county taxes, and when made to the collector he must credit the amount paid to the person named in the certificate, and pay it, on demand, to the person or his assignees. In each report the collector makes to the board of directors he must name the person entitled to redemption money, and the amount due to each. On receiving the certificate of sale, the county recorder must file it and make an entry in a book similar to that required of the collector. On the presentation of the receipt of the person named in the certificate, or of the collector for his use, of the total amount of redemption money, the recorder must mark the word "redeemed," the date, and by whom redeemed, on the certificate and on the margin of the book where the entry of the certificate is made. If the property is not redeemed within twelve months from the sale, the collector or his successor in office must make to the purchaser or his assignee a deed of the property, reciting in the deed substantially the matters contained in the certificate, and that no person redeemed the property during the time allowed by law for its redemption. The collector shall receive from the purchaser, for the use of the district, two dollars for making such deed.

SEC. 30. The matter recited in the certificate of sale must be recited in the deed, and such deed duly acknowledged or proved is prima facie evidence that—

First. The property was assessed as required by law.

Second. The property was equalized as required by law.

Third. That the assessments were levied in accordance with law.

Fourth. The assessments were not paid.

Fifth. At a proper time and place the property was sold as prescribed by law and by the proper officer.

Sixth. The property was not redeemed.

Seventh. The person who executed the deed was the proper officer.

Such deed, duly acknowledged or proved, is (except as against actual fraud) conclusive evidence of the regularity of all the proceedings from the assessment by the assessor, inclusive, up to the execution of the deed. The deed conveys to the grantee the absolute title to the lands described therein, free of all incumbrances, except when the land is owned by the United States or this State, in which case it is prima facie evidence of the right of possession.

SEC. 31. The assessment book or delinquent list, or a copy thereof, certified by the collector, showing unpaid assessments against any person or property, is prima facie evidence of the assessment, the property assessed, the delinquency, the amount of assessments due and unpaid, and that all the forms of the law in relation to the assessment and levy of such assessments have been complied with.

SEC. 32. When land is sold for assessments correctly imposed, as the property of a particular person, no misnomer of the owner, or supposed owner, or other mistake relating to the ownership thereof, affects the sale or renders it void or voidable.

SEC. 33. On the first Monday in each month the collector must settle with the secretary of the board for all moneys collected for assessments, and pay the same over to the treasurer; and within six days thereafter he must deliver to and file in the office of the secretary a statement under oath, showing:

First. An account of all his transactions and receipts since his last settlement.

Second. That all money collected by him as collector has been paid.

The collector shall also file in the office of the secretary on said first Monday in each month the receipt of the treasurer for the money so paid.

SEC. 34. Upon the presentation of the coupons due to the treasurer, he shall pay the same from said bond fund. Whenever, after ten years from the issuance of said bonds, said fund shall amount to the sum of ten thousand dollars, the board of directory may direct the treasurer to pay such an amount of said bonds not due as the money in said fund will redeem, at the lowest value at which they may be offered for liquidation, after advertising for at least four weeks in some daily newspaper in each of the cities hereinbefore named, and in any other newspaper which said board

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deem advisable, for sealed proposals for the redemption of said bonds. Said
osals shall be opened by the board in open meeting, at a time to be named in the
e, and the lowest bid for said bonds must be accepted: *Provided*, That no bond
be redeemed at a rate above par. In case the bids are equal the lowest num-
l bond shall have the preference. In case none of the holders of said bonds shall
e to have the same redeemed, as herein provided for, said money shall be invested
ie treasurer, under the direction of the board, in United States gold-bearing
s, or the bonds of the State, which shall be kept in said "bond fund," and may
ed to redeem said district bonds whenever the holders thereof may desire.

. 35. After adopting a plan of said canal or canals, storage, reservoirs, and
s, the board of directors shall give notice, by publication thereof not less than
ty days in one newspaper published in each of the counties composing the dis-
provided a newspaper is published therein, and in such other newspapers as
may deem advisable, calling for bids for the construction of said work, or of any
on thereof; if less than the whole work is advertised, then the portion so adver-
must be particularly described in such notice; said notice shall set forth that
and specifications can be seen at the office of the board, and that the board will
ve sealed proposals therefor, and that the contract will be let to the lowest re-
ible bidder, stating the time and place for opening said proposals, which at the
and place appointed shall be opened in public, and as soon as convenient there-
the board shall let said work, either in portions or as a whole, to the lowest re-
ible bidder, or they may reject any or all bids and readvertise for proposals, or
proceed to construct the work under their own superintendence with the labor
e residents of the district. Contracts for the purchase of material shall be
ded to the lowest responsible bidder. Any person or persons to whom a con-
may be awarded shall enter into a bond, with good and sufficient sureties, to
proved by the board, payable to said district for its use, for double the amount
e contract price, conditional for the faithful performance of said contract. The
shall be done under the direction and to the satisfaction of the engineer, and
proved by the board.

. 36. No claim shall be paid by the treasurer until allowed by the board, and
upon a warrant signed by the president, and countersigned by the secretary:
ded, That the board may draw from time to time from the construction fund and
it in the county treasury of the county where the office of the board is situ-
any sum in excess of the sum of twenty-five thousand dollars. The county
urer of said county is hereby authorized and required to receive and receipt for
ame, and place the same to the credit of said district, and he shall be responsi-
pon his official bond for the safe-keeping and disbursement of the same, as in
ct provided. He shall pay out the same, or any portion thereof, to the treas-
of the district only, and only upon the order of the board, signed by the presi-
and attested by the secretary. The said county treasurer shall report in writ-
n the second Monday in each month the amount of money in the county
ury, the amount of receipts for the month preceding, and the amount or
nts paid out; said report shall be verified and filed with the secretary of the
. The district treasurer shall also report to the board, in writing, on the first
ay in each month, the amount of money in the district treasury, the amount
eipts for the month preceding, and the amount and items of expenditures, and
eport shall be verified and filed with the secretary of the board.

. 37. The cost and the expense of purchasing and acquiring property and con-
ing the works and improvements herein provided for, shall be wholly paid out of
nstruction fund. For the purpose of defraying the expenses of the organization
e district, and of the care, operation, management, repair, and improvement of
portions of said canal and works as are completed and in use, including salaries
cers and employés, the board may either fix rates of tolls and charges, and col-
he same from all persons using said canal for irrigation and other purposes, or
may provide for the payment of said expenditures by a levy of assessments there-
r by both said tolls and assessments; if by the latter method such levy shall be
of the completion and equalization of the assessment roll, and the board shall
the same powers and functions for the purposes of said levy as are now possessed
ards of supervisors in this State. The procedure for the collection of assessments
ch levy shall in all respects conform to the provisions of this act relating to the
ent of principal and interest of bonds herein provided for.

. 38. The board of directors shall have power to construct the said works across
tream of water, water-course, street, avenue, highway, railway, canal, ditch, or
which the route of said canal or canals may intersect or cross, in such manner
afford security for life and property; but said board shall restore the same, when
ssed or intersected, to its former state as near as may be, or in a sufficient manner
have impaired unnecessarily its usefulness; and every company whose railroad
be intersected or crossed by said works shall unite with said board in forming
ntersections and crossings, and grant the privileges aforesaid; and if such rail-

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road company and said board, or the owners and controllers of the said property, thing, or franchise so to be crossed, can not agree upon the amount to be paid therefor, or the points or the manner of said crossings or intersections, the same shall be ascertained and determined in all respects as is herein provided in respect to the taking of land. The right of way is hereby given, dedicated, and set apart, to locate, construct, and maintain said works over and through any of the lands which are now, or may be, the property of this State; and also there is given, dedicated, and set apart, for the uses and purposes aforesaid, all waters and water-rights belonging to this State within the district.

SEC. 39. The board of directors shall each receive four dollars per day, and mileage at the rate of twenty cents per mile, in attending meetings, and actual and necessary expenses paid while engaged in official business under the order of the board. The board shall fix the compensation to be paid to the other officers named in the act, to be paid out of the treasury of the district: *Provided*, That said board shall, upon the the petition of at least fifty, or a majority of the freeholders within such district therefor, submit to the electors at any general election a schedule of salaries and fees to be paid hereunder. Such petition must be presented to the board twenty days prior to a general election, and the result of such election shall be determined and declared in all respects as other elections are determined and declared under this act.

SEC. 40. No director or any other officer named in this act shall in any manner be interested, directly or indirectly, in any contract awarded or to be awarded by the board, or in the profits to be derived therefrom; and for any violation of this provision, such officer shall be deemed guilty of a misdemeanor, and such conviction shall work a forfeiture of his office, and he shall be punished by a fine not exceeding five hundred dollars, or by imprisonment in the county jail not exceeding six months, or by both such fine and imprisonment.

SEC. 41. The board of directors may, at any time, when in their judgment it may be advisable, call a special election, and submit to the qualified electors of the district the question whether or not a special assessment shall be levied for the purpose of raising money to be applied to any of the purposes provided in this act. Such election must be called upon the notice prescribed, and the same shall be held, and the result thereof determined and declared in all respects in conformity with the provisions of section fifteen of this act. The notice must specify the amount of money proposed to be raised, and the purpose for which it is intended to be used. At such elections the ballots shall contain the words, "Assessment—yes," or "Assessment—no." If two-thirds or more of the votes cast are "Assessment—yes," the board shall, at the time of the annual levy hereunder, levy an assessment sufficient to raise the amount voted. The rate of assessment shall be ascertained by deducting fifteen per cent. for anticipated delinquencies from the aggregate assessed value of the property in the district as it appears on the assessment roll for the current year, and then dividing the sum voted by the remainder of such aggregate assessed value. The assessment so levied shall be computed and entered on the assessment roll by the secretary of the board, and collected at the same time and in the same manner as other assessments provided for herein; and when collected shall be paid into the district treasury for the purposes specified in the notice of such special election.

SEC. 42. The board of directors, or other officers of the district, shall have no power to incur any debt or liability whatever, either by issuing bonds, or otherwise, in excess of the express provisions of this act, and any debt or liability incurred in excess of such express provisions shall be and remain absolutely void.

SEC. 43. In case the volume of water in any stream or river shall not be sufficient to supply the continual wants of the entire country through which it passes, and susceptible of irrigation therefrom, then it shall be the duty of the water commissioners, constituted as hereinafter provided, to apportion, in a just and equitable proportion, a certain amount of said water upon certain or alternate weekly days to different localities, as they may, in their judgment, think best for the interest of all parties concerned, and with due regard to the legal and equitable rights of all. Said water commissioners shall consist of the chairman of the board of directors of each of the districts affected.

SEC. 44. It shall be the duty of the board of directors to keep the water flowing through the ditches under their control to the full capacity of such ditches in times of high water.

SEC. 45. Navigation shall never in anywise be impaired by the operation of this act, nor shall any vested interest in or to any mining water rights or ditches, or in or to any water or water rights, or reservoirs, or dams now used by the owners or possessors thereof in connection with any mining industry, or by persons purchasing or renting the use thereof, or in or to any other property now used directly or indirectly in carrying on or promoting the mining industry, ever be affected by or taken under its provisions save and except that rights of way may be acquired over the same.

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SEC. 46. None of the provisions of this act shall be construed as repealing or in anywise modifying the provisions of any other act relating to the subject of irrigation or water commissioners. Nothing herein contained shall be deemed to authorize any person or persons to divert the waters of any river, creek, stream, canal, or ditch from its channel to the detriment of any person or persons having any interest in such river, creek, stream, canal, or ditch, or the waters therein, unless previous compensation be ascertained and paid therefor under the laws of this State authorizing the taking of private property for public uses.

CHAPTER XIX. AN ACT TO AMEND SECTIONS 10, 22, AND 27 OF FOREGOING ACT.

SECTION 1. Section ten of said act is hereby amended to read as follows:

Section 10. The secretary of the board of directors must, as soon as the result is declared, enter in the records of such board a statement of such result, which statement must show—

First. The whole number of votes cast in the district and in each division of the district.

Second. The names of the persons voted for.

Third. The office to fill which each person was voted for.

Fourth. The number of votes given in each precinct to each of such persons.

Fifth. The number of votes given in each division for the office of director, and the number of votes given in the district for the offices of assessor, collector, and treasurer.

The board of directors must declare elected the persons having the highest number of votes given for each office. The secretary must immediately make out and deliver to such person a certificate of election, signed by him and authenticated with the seal of the board. In case of the vacancy in the office of assessor, collector, or treasurer the vacancy shall be filled by appointment of the board of directors. In case of a vacancy in the office of director the vacancy shall be filled by appointment by the board of supervisors of the county where the office of such board of directors is situated from the division in which the vacancy occurred. An officer appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 2. Section twenty-two of said act is hereby amended to read as follows:

Section 22. The board of directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds, and at the expiration of ten years after the issuing of bonds by the board must increase said assessment for the ensuing ten years in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent.; for the twelfth year six per cent.; for the thirteenth year, seven per cent.; for the fourteenth year, eight per cent.; for the fifteenth year, nine per cent.; for the sixteenth year, ten per cent.; for the seventeenth year, eleven per cent.; for the eighteenth year, thirteen per cent.; for the nineteenth year, fifteen per cent.; and for the twentieth year, a percentage sufficient to pay off said bonds. The secretary of the board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment on the property therein enumerated. When collected the assessment shall be paid into the district treasury, and shall constitute a special fund, to be called the "bond fund of ——— irrigation district." In case of the neglect or refusal of the board of directors to cause such assessment and levy to be made as in this act provided, then the assessment of property made by the county assessor and the State board of equalization shall be adopted and shall be the basis of assessments for the district, and the board of supervisors of the county in which the office of the board of directors is situated shall cause an assessment roll for said district to be prepared, and shall make the levy required by this act in the same manner and with like effect as if the same had been made by said board of directors, and all expenses incident thereto shall be borne by such district. In case of the neglect or refusal of the collector or treasurer of the district to perform the duties imposed by law, then the tax collector and treasurer of the county in which the office of the board of directors is situated must, respectively, perform such duties, and shall be accountable therefor upon their official bonds as in other cases.

SEC. 3. Section twenty-seven of said act is hereby amended to read as follows:

Section 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the collector, prior to the sale, what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the collector for the duplicate certificate of sale, is the purchaser. If the purchaser does not pay the assessments and costs before ten o'clock a. m. the following day the property on the next sale day must be resold for the assessments and

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costs. But in case there is no purchaser in good faith for the same on the first day that the property is offered for sale, then, when the property is offered thereafter for sale and there is no purchaser in good faith for the same, the whole amount of the property assessed shall be struck off to the irrigation district within which such lands are situated as the purchaser, and the duplicate certificate delivered to the treasurer of the district and filed by him in his office. No charge shall be made for the duplicate certificate where the district is the purchaser, and, in such case, the collector shall make an entry, "sold to the district," and he shall be credited with the amount thereof in his settlement. An irrigation district, as a purchaser at such sale, shall be entitled to the same rights as a private purchaser, and the title so acquired by the district, subject to the right of redemption herein provided, may be conveyed by deed, executed and acknowledged by the president and secretary of said board: *Provided*, That authority to so convey must be conferred by resolution of the board, entered on its minutes, fixing the price at which such sale may be made, and such conveyance shall not be made for a less sum than the reasonable market value of such property. After receiving the amount of assessments and costs the collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the names of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the collector, and one copy delivered to the purchaser and the other filed in the office of the county recorder of the county in which the land is situated.

Chapter XX. An Act Amendatory of and Supplemental.

Section 1. The boundaries of any irrigation district now or hereafter organized under the provisions of an act, entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March 7, 1887, may be changed in the manner herein prescribed; but such change of the boundaries of the district shall not impair or affect its organization, or its rights in or to property, or any of its rights or privileges of whatsoever kind or nature; nor shall it affect, impair, or discharge any contract, obligation, lien, or charge for or upon which it was or might become liable or chargeable had such change of its boundaries not been made.

Sec. 2. The holder or holders of title, or evidence of title, representing one-half or more of any body of lands adjacent to the boundary of an irrigation district, which are contiguous, and which, taken together, constitute one tract of land, may file with the board of directors of said district a petition in writing, praying that the boundaries of said district may be so changed as to include therein said lands. The petition shall describe the boundaries of said parcel or tract of land, and shall also described the boundaries of the several parcels owned by the petitioners, if the petitioners be the owners, respectively, of distinct parcels, but such descriptions need not be more particular than they are required to be when such lands are entered by the county assessor in the assessment book. Such petition must contain the assent of the petitioners to the inclusion within said district of the parcels or tracts of land described in the petition, and of which said petition alleges they are respectively the owners; and it must be acknowledged in the same manner that conveyances of land are required to be acknowledged.

Sec. 3. The secretary of the board of directors shall cause a notice of the filing of such petition to be given and published in the same manner and for the same time that notices of special elections for the issue of bonds are required by said act to be published. The notice shall state the filing of such petition and the names of the petitioners, a description of the lands mentioned in said petition and the prayers of said petition; and it shall notify all persons interested in or that may be affected by such change of the boundaries of the district to appear at the office of said board at a time named in said notice and show cause in writing, if any they have, why the change in the boundaries of said district, as proposed in said petition, should not be made. The time to be specified in the notice at which they shall be required to show cause shall be the regular meeting of the board next after the expiration of the time for the publication of the notice. The petitioners shall advance to the secretary sufficient money to pay the estimated costs of all proceedings under this act.

Sec. 4. The board of directors, at the time and place mentioned in the said notice, or at such other time or times to which the hearing of said petition may be adjourned, shall proceed to hear the petition, and all the objections thereto, presented in writing by any person showing cause as aforesaid why said proposed change of the boundaries of the district should not be made. The failure by any person interested in said district, or in the matter of the proposed change of its boundaries, to show cause, in writing, as aforesaid, shall be deemed and taken as an assent on his part to a change

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of the boundaries of the district as prayed for in said petition, or to such a change thereof as will include a part of said lands. And the filing of such petition with said board, as aforesaid, shall be deemed and taken as an assent on the part of each and all of such petitioners to such a change of said boundaries that they may include the whole or any portion of the lands described in said petition.

SEC. 5. The board of directors, to whom such petition is presented, may require as a condition precedent to the granting of the same, that the petitioners shall severally pay to such district such respective sums, as nearly as the same can be estimated (the several amounts to be determined by the board), as said petitioners or their grantors would have been required to pay to such district as assessments had such lands been included in such district at the time the same was originally formed.

SEC. 6. The board of directors, if they deem it not for the best interests of the district that a change of its boundaries be so made as to include therein the lands mentioned in the petition, shall order that the petition be rejected. But if they deem it for the best interests of the district that the boundaries of said district be changed, and if no person interested in said district or the proposed change of its boundaries shows cause in writing why the proposed change should not be made, or if, having shown cause, withdraws the same, the board may order that the boundaries of the district be so changed as to include therein the lands mentioned in said petition, or some part thereof. The order shall describe the boundaries as changed, and shall also describe the entire boundaries of the district as they will be after the change thereof as aforesaid is made; and for that purpose the board may cause a survey to be made of such portions of such boundary as is deemed necessary.

SEC. 7. If any person interested in said district, or the proposed change of its boundaries, shall show cause, as aforesaid, why such boundaries should not be changed, and shall not withdraw the same, and if the board of directors deem it for the best interest of the district that the boundaries thereof be so changed as to include therein the lands mentioned in the petition, or some part thereof, the board shall adopt a resolution to that effect. The resolution shall describe the exterior boundaries of the lands which the board are of the opinion should be included within the boundaries of the district when changed.

SEC. 8. Upon the adoption of the resolution mentioned in the last preceding section, the board shall order that an election be held within said district, to determine whether the boundaries of the district shall be changed as mentioned in said resolution; and shall fix the time at which such election shall be held, and cause notice thereof to be given and published. Such notice shall be given and published, and such election shall be held and conducted, the returns thereof shall be made and canvassed, and the result of the election ascertained and declared, and all things pertaining thereto conducted in the manner prescribed by said act in case of a special election to determine whether bonds of an irrigation district shall be issued. The ballots cast at said election shall contain the words "For change of boundary," or "Against change of boundary," or words equivalent thereto. The notice of election shall describe the proposed change of the boundaries in such manner and terms that it can readily be traced.

SEC. 9. If at such election a majority of all the votes cast at said election shall be against such change of the boundaries of the district, the board shall order that said petition be denied, and shall proceed no further in that matter. But if a majority of such votes be in favor of such change of the boundaries of the district, the board shall thereupon order that the boundaries be changed in accordance with said resolution adopted by the board. The said order shall describe the entire boundaries of said district, and for that purpose the board may cause a survey of such portions thereof to be made as the board may deem necessary.

SEC. 10. Upon a change of the boundaries of a district being made, a copy of the order of the board of directors ordering such change, certified by the president and secretary of the board, shall be filed for record in the recorder's office of each county within which are situated any of the lands of the district, and thereupon the district shall be and remain an irrigation district, as fully and to every intent and purpose as if the lands which are included in the district by the change of the boundaries, as aforesaid, had been included therein at the original organization of the district.

SEC. 11. Upon the filing of the copies of the order, as in the last preceding section mentioned, the secretary shall record in the minutes of the board the petition aforesaid; and the said minutes, or a certified copy thereof, shall be admissible in evidence with the same effect as the petition.

SEC. 12. A guardian, an executor, or an administrator of an estate, who is appointed as such under the laws of this State, and who, as such guardian, executor, or administrator, is entitled to the possession of the lands belonging to the estate which he represents, may, on behalf of his ward or the estate which he represents, upon being thereunto authorized by the proper court, sign and acknowledge the petition in this act mentioned, and may show cause, as in this act mentioned, why the boundaries of the district should not be changed.

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SEC. 13. In case of the inclusion of any land within any district by proceedings under this act, the board of directors must, at least thirty days prior to the next succeeding general election, make an order re-dividing such district into five divisions, as nearly equal in size as may be practicable, which shall be numbered First, Second, Third, Fourth, and Fifth, and one director shall thereafter be elected by each division. For the purposes of elections the board of directors must establish a convenient number of election precincts in said districts, and define the boundaries thereof, which said precincts may be changed from time to time, as the board may deem necessary.

CHAPTER XXI. AN ACT AMENDATORY OF AND SUPPLEMENTAL.

SECTION 1. The boundaries of any irrigation district, now or hereafter organized under the provisions of an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, one thousand eight hundred and eighty-seven, may be changed, and tracts of land which were included within the boundaries of such district, at or after its organization under the provisions of said act, may be excluded therefrom, in the manner herein prescribed; but neither such change of the boundaries of the district, nor such exclusion of lands from the district, shall impair or affect its organization, or its right in or to property, or any of its rights or privileges, of whatever kind or nature; nor shall it affect, impair, or discharge any contract, obligation, lien, or charge for or upon which it was or might become liable or chargeable had such change of its boundaries not been made, or had not any land been excluded from the district.

SEC. 2. The owner or owners in fee of one or more tracts of land which constitute a portion of an irrigation district, may file with the board of directors of the district a petition, praying that such tracts and any other tracts contiguous thereto may be excluded and taken from said district. The petition shall describe the boundaries of the land which the petitioners desire to have excluded from the district, and also the lands of each of such petitioners, which are included within such boundaries; but the description of such lands need not be more particular or certain than is required when the lands are entered in the assessment book by the county assessor. Such petition must be acknowledged in the same manner and form as is required in case of a conveyance of land, and the acknowledgment shall have the same force and effect as evidence as the acknowledgment of such conveyance.

SEC. 3. The secretary of the board of directors shall cause a notice of the filing of such petition to be published for at least two weeks in some newspaper published in the county where the office of the board of directors is situated, and if any portion of such territory to be excluded lie within another county or counties, then said notice shall be so published in a newspaper published within each of said counties; or if no newspaper be published therein, then by posting such notice for the same time in at least three public places in said district, and, in case of the posting of said notices, one of said notices must be so posted on the lands proposed to be excluded. The notice shall state the filing of such petition; the names of the petitioners; a description of the lands mentioned in said petition, and the prayer of said petition; and it shall notify all persons interested in or that may be affected by such change of the boundaries of the district, to appear at the office of said board at a time named in said notice, and show cause in writing, if any they have, why the change of the boundaries of said district, as proposed in said petition, should not be made. The time to be specified in the notice at which they shall be required to show cause shall be the regular meeting of the board next after the expiration of the time for the publication of the notice.

SEC. 4. The board of directors, at the time and place mentioned in the notice, or at the time or times to which the hearing of said petition may be adjourned, shall proceed to hear the petition and all objections thereto presented in writing by any person showing cause as aforesaid why the prayer of said petition should not be granted. The failure of any person interested in said district to show cause in writing why the tract or tracts of land mentioned in said petition should not be excluded from said district, shall be deemed and taken as an assent by him to the exclusion of such tract or tracts of land, or any part thereof, from said district; and the filing of such petition with such board, as aforesaid, shall be deemed and taken as an assent by each and all of such petitioners to the exclusion from such district of the lands mentioned in the petition, or any part thereof.

SEC. 5. The board of directors, if they deem it not for the best interest of the district that the lands mentioned in the petition, or some portion thereof, should be excluded from said district, shall order that said petition be denied; but if they deem it for the best interests of the district that the lands mentioned in the petition, or some portion thereof, be excluded from the district, and if no person interested in the dis-

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trict show cause in writing why the said lands, or some portion thereof, should not be excluded from the district, or if, having shown cause, withdraws the same, and also, if there be no outstanding bonds of the district, then the board may order that the lands mentioned in the petition, or some defined portion thereof, be excluded from the district.

SEC. 6. If there be outstanding bonds of the district, then the board may adopt a resolution to the effect that the board deems it to the best interest of the district that the lands mentioned in the petition, or some portion thereof, should be excluded from the district. The resolution shall describe such lands so that the boundaries thereof can readily be traced. The holders of such outstanding bonds may give their assent in writing to the effect that they severally consent that the board may make an order by which the lands mentioned in the resolution may be excluded from the district. The assent must be acknowledged by the several holders of such bonds in the same manner and form as is required in case of a conveyance of land, and the acknowledgment shall have the same force and effect as evidence as the acknowledgment of such conveyance. The assent shall be filed with the board and must be recorded in the minutes of the board; and said minutes, or a certified copy thereof, shall be admissible in evidence with the same effect as the said assent; but if such assent be not filed, the board shall deny and dismiss said petition.

SEC. 7. If the assent aforesaid of the holders of said bonds be filed and entered of record as aforesaid, and if there be objections presented by any person showing cause as aforesaid, which have not been withdrawn, then the board may order an election to be held in said district to determine whether an order shall be made excluding said land from the district as mentioned in said resolution. The notice of such election shall describe the boundary of all lands which it is proposed to exclude, and such notice shall be published for at least two weeks prior to such election in a newspaper published within the county where the office of the board of directors is situated; and if any portion of such territory to be excluded lie within another county or counties, then said notice shall be so published in a newspaper published within each of such counties. Such notice shall require the electors to cast ballots which shall contain the words "For Exclusion," or "Against Exclusion," or words equivalent thereto. Such election shall be conducted in accordance with the general election laws of the State: *Provided*, That no particular form of ballot shall be required.

SEC. 8. If at such election a majority of all the votes cast shall be against the exclusion of said lands from the district, the board shall deny and dismiss said petition and proceed no further in said matter; but if a majority of such votes be in favor of the exclusion of said lands from the district the board shall thereupon order that the said lands mentioned in said resolution be excluded from the district. The said order shall describe the boundaries of the district should the exclusion of the said lands from said district change the boundaries of the district, and for that purpose the board may cause a survey to be made of such portions of the boundaries as the board may deem necessary.

SEC. 9. Upon the entry in the minutes of the board of any of the orders hereinbefore mentioned, a copy thereof, certified by the president and the secretary of the board, shall be filed for record in the recorder's office of each county within which are situated any of the lands of the district, and thereupon said district shall be and remain an irrigation district as fully, to every intent and purpose, as it would be had no change been made in the boundaries of the district, or had the lands excluded therefrom never constituted a portion of the district.

SEC. 10. If the lands excluded from any district under this act shall embrace the greater portion of any division or divisions of such district, then the office of director for such division or divisions shall become and be vacant at the expiration of ten days from the final order of the board, under section eight of this act excluding said lands, and such vacancies shall be filled by appointment by the board of supervisors of the county where the office of such board is situated from the district at large. A director appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 11. At least thirty days before the next general election of such district the board of directors thereof shall make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered first, second, third, fourth, and fifth, and one director shall be elected by each division. For the purposes of elections in such district the said board of directors must establish a convenient number of election precincts, and define the boundaries thereof, which said precincts may be changed from time to time, as the board of directors may deem necessary.

SEC. 12. A guardian, an executor, or an administrator of an estate, who is appointed as such under the laws of this State, and who, as such guardian, executor, or administrator, is entitled to the possession of the lands belonging to the estate which he represents, may, on behalf of his ward or the estate which he represents, upon being

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thereto properly authorized by the proper court, sign and acknowledge the petition in this act mentioned, and may show cause, as in this act provided, why the boundaries of the district should not be changed.

SEC. 13. In case of the exclusion of any lands under the provisions of this act, there shall be refunded to any and all persons who have paid any assessment or assessments to such district, or any lands so excluded, any sum or sums so paid. Such payments shall be made in the same manner as other claims against such district, and from such fund or funds as the board of directors may designate.

CHAPTER CLXXVIII. AN ACT SUPPLEMENTAL.

SECTION 1. The board of directors of an irrigation district now or hereafter organized under the provisions of the act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, eighteen hundred and eighty-seven, may commence a special proceeding, in and by which the proceedings of said board and of said district providing for and authorizing the issue and sale of the bonds of said district, whether said bonds or any of them have or have not then been sold, may be judicially examined, approved, and confirmed.

SEC. 2. The board of directors of the irrigation district shall file in the superior court of the county in which the lands of the district or some portion thereof are situated a petition praying, in effect, that the proceedings aforesaid may be examined, approved, and confirmed by the court. The petition shall state the facts showing the proceedings had for the issue and sale of said bonds, and shall state generally that the irrigation district was duly organized, and that the first board of directors was duly elected; but the petition need not state the facts showing such organization of the district, or the election of said first board of directors.

SEC. 3. The court shall fix the time for the hearing of said petition, and shall order the clerk of the court to give and publish a notice of the filing of said petition. The notice shall be given and published in the same manner and for the same length of time that the notice of a special election provided for by said act to determine whether the bonds of said district shall be issued is required to be given and published. The notice shall state the time and place fixed for the hearing of the petition and the prayer of the petition, and that any person interested in the organization of said district, or in the proceedings for the issue or sale of said bonds, may, on or before the day fixed for the hearing of said petition, demur to or answer said petition. The petition may be referred to and described in said notice as the petition of the board of directors of —— irrigation district (giving its name), praying that the proceedings for the issue and sale of the bonds of said district may be examined, approved, and confirmed by said court.

SEC. 4. Any person interested in said district, or in the issue or sale of said bonds, may demur to or answer said petition. The provisions of the code of civil procedure respecting the demurrer and the answer to a verified complaint shall be applicable to a demurrer and answer to said petition. The persons so demurring to or answering said petition shall be the defendants to said special proceeding, and the board of directors shall be the plaintiff. Every material statement of the petition not specifically controverted by the answer must, for the purpose of said special proceeding, be taken as true, and each person failing to answer the petition shall be deemed to admit as true all the material statements of the petition. The rules of pleading and practice provided by the code of civil procedure which are not inconsistent with the provisions of this act are applicable to the special proceeding herein provided for. A motion for a new trial must be made upon the minutes of the court. The order granting a new trial must specify the issues to be re-examined on such new trial, and the findings of the court upon the other issues shall not be affected by such order granting a new trial.

SEC. 5. Upon the hearing of such special proceeding the court shall have power and jurisdiction to examine and determine the legality and validity of, and approve and confirm, each and all of the proceedings for the organization of said district under the provisions of the said act, from and including the petition for the organization of the district, and all other proceedings which may affect the legality or validity of said bonds, and the order for the sale, and the sale thereof. The court, in inquiring into the regularity, legality, or correctness of said proceedings, must disregard any error, irregularity, or omission which does not affect the substantial rights of the parties to said special proceeding; and it may approve and confirm such proceedings in part, and disapprove and declare illegal or invalid other and subsequent parts of the proceedings. The court shall find and determine whether the notice of the filing of said petition has been duly given and published for the time and in the manner in this act prescribed. The costs of the special proceedings may be allowed and apportioned between all the parties, in the discretion of the court.

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SEC. 6. An appeal from an order granting or refusing a new trial, or from the judgment, must be taken by the party aggrieved within ten days after the entry of said order or said judgment.*

COLORADO IRRIGATION LAWS.

All persons who claim, own, or hold a possessory right or title to any land or parcel of land lying within the boundary of the State of Colorado, as defined in the constitution of said State, when those claims are on the bank, margin, or neighborhood of any stream of water, creek, or river, shall be entitled to the use of the water of said stream, creek, or river, for the purpose of irrigation and making said claims available to the full extent of the soil for agricultural purposes. General Statutes, 1711, (1861).

Nothing in this chapter contained shall be so construed as to impair the prior vested rights of any mill or ditch owner or other person to use the water of any such water-course.

Under the provisions of this act [*eminent domain*] private property may be taken for private use, for private ways of necessity, for reservoirs, drains, flumes, or ditches on or across the land of others for agricultural, mining, milling, domestic, or sanitary purposes. (Session Laws of 1885, pp. 201, 202, 1729.)

Every person, association, or corporation hereafter constructing or enlarging any ditch, canal, or feeder for any reservoir, for irrigation, and taking water directly from any natural stream, and of a carrying capacity of one cubic foot per second of time as so constructed or enlarged, shall within ninety days after the commencement of such construction or enlargement file and cause to be recorded in the office of the county clerk of the county in which such ditch, canal, or feeder may be situated, or if such canal, ditch, or feeder be situated in any water district, in the office of the county clerk of such [each] county in which such water district may extend, a sworn statement in writing, showing the name of such ditch, canal, or of the reservoir supplied by such feeder, the point at which the head-gate thereof is situated (if it be a new construction), the size of the ditch, canal, or feeder in width and depth and the carrying capacity thereof in cubic feet per second, the description of the line thereof and the time when the work was commenced, and the name or names of the owner or owners thereof, together with a map showing the route thereof, the legal subdivisions of the land, if on surveyed lands with proper corners and distances, and in case of an enlargement the depth and width also the carrying capacity of the ditch enlarged, with the width and depth of the ditch, canal, or feeder as enlarged, and the increased carrying capacity of the same thereby occasioned, and the time when such enlargement was commenced, and no priority of right for any purpose shall attach to any such construction or enlargement until record is made. (Sec. 2, p. 162, Acts 1881, 1720.)

This act shall apply to and affect only ditches, canals, or feeders used for carrying water for the purposes of irrigation and for no other purposes whatever. (Sec. 3, p. 162, Acts 1881, 1721.)

Any company formed under the provisions of this (corporations) act, for the purpose of constructing any ditch, flume, * * * shall, within ninety days from the date of their certificate, commence work on such ditch, flume * * * line as shall be named in the certificate, and shall prosecute the work with due diligence until the same is completed, and the time of completion of any such ditch * * * line shall not be extended beyond a period of two years from the time work was commenced as aforesaid; and any company failing to commence work within ninety days from the date of the certificate, or failing to complete the same within two years from the time of commencement as aforesaid, shall forfeit all right to the water so claimed, and the same shall be subject to be claimed by any other company; the time for the completion of any flume constructed under the provisions of this act shall not be extended beyond a period of four years: *Provided*, This section shall not apply to any ditch or flume * * * constructed through and upon any grounds owned by the corporation: *And provided further*, That any company formed under the provisions of this act to construct a ditch for domestic, agricultural, irrigating * * * purposes, or any or either thereof, shall have three years from the time of commencing work thereon within which to complete the same, but no longer. (Sec. 296 (106), pp. 179, 80, G. L., 314.)

All persons on the margin, brink, neighborhood, or precinct of any stream of water shall have the right and power to place upon the bank of said stream a wheel or other machine for the purpose of raising water to the level required for the purpose of irrigation. (Sec. 8, pp. 68, 69, Acts 1861; sec. 6, p. 364, R. S.; sec. 1377 (6) p. 516, G. L., 1727.)

All persons who shall have enjoyed the use of the water in any natural stream, for the irrigation of any meadow land, by the natural overflow or operation of the water

* All these acts took effect from and after their passage.

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of such stream, shall, in case the diminishing of the water supplied from such stream from any cause prevents such irrigation therefrom in as ample a manner as formerly, have right to construct a ditch for the irrigation of such meadow and to take water from such stream therefor, and his, her or their right to water through such ditch shall have the same priority as though such ditch had been constructed at the time he, she or they first occupied and used such land as meadow ground. (Sec. 37, p. 106, Acts 1879, 1723.)

In case the channel of any natural stream shall become so cut out, lowered, turned aside or otherwise changed from any cause as to prevent any ditch, canal, or feeder of any reservoir from receiving the proper inflow of water to which it may be entitled from such natural stream, the owner or owners of such ditch, canal or feeder shall have the right to extend the head of such ditch, canal or feeder to such distance up the stream which supplies the same as may be necessary for securing a sufficient flow of water into the same, and for that purpose shall have the same right to maintain proceedings for condemnation of right of way for such extension as in case of constructing a new ditch, and the priority of right to take water from such stream through such ditch, canal or feeder, as to any such ditch, canal, or feeder, shall remain unaffected in any respect by reason of such extension: *Provided, however*, That no such extension shall interfere with the complete use or enjoyment of any other ditch, canal or feeder. (Sec. 1, pp. 161, 162, Acts 1881, 1719.)

For the purpose of hearing, adjudicating, and settling all questions concerning the priority of appropriation of water between ditch companies and other owners of ditches drawing water for irrigation purposes from the same stream or its tributaries within the same water district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested exclusively in the district court of the proper county; but when any water district shall extend into two or more counties the district court of the county in which the first regular term after the 1st day of December in each year shall soonest occur, according to the law then in force, shall be the proper court in which the proceedings for said purpose, as hereinafter provided for, shall be commenced; but where said proceedings shall be once commenced by the entry of an order appointing a referee in the manner and for the purpose hereinafter in this act provided, such court shall thereafter retain exclusive jurisdiction of the whole subject until final adjudication thereof is had, notwithstanding any law to the contrary now in force. (Sec. 19, pp. 99, 100, Acts 1879, 1762.)

In order that all parties may be protected in their lawful rights to the use of water for irrigation, every person, association, or corporation owning or claiming any interest in any ditch, canal, or reservoir, within any water district, shall, on or before the 1st day of June, A. D. 1881, file with the clerk of the district court having jurisdiction of priority of right to the use of water for irrigation in such water district a statement of claim, under oath, entitled of the proper court, and in the matter of priorities of water rights in district number * * *, as the case may be, which statement shall contain the name or names, together with the post-office address of the claimant or claimants claiming ownership, as aforesaid, of any such ditch, canal, or reservoir, the name thereof (if any), and, if without a name, the owner or owners shall choose and adopt a name, to be therein stated, by which such ditch, canal, or reservoir shall thereafter be known, the description of such ditch, canal, or reservoir, as to location of head-gate, general course of ditch, the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water, the length, width, depth, and grade thereof, as near as may be, the time, fixing a day, month, and year as the date of the appropriation of water by original construction, also by any enlargement or extension, if any such thereof may have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder of reservoir, and also the number of acres of land lying under and being or proposed to be irrigated by water from such ditch, canal, or reservoir. Said statement shall be signed by the proper party or parties. (Sec. 1, pp. 142, 143, Acts 1881, 1763.)

The secretary of state shall, without delay, after the passage of this act, cause a certified copy of the foregoing section, giving the date of the approval of this act, to be published in one of the public newspapers published in such county in which part or portion of any water district is or shall be established by law at the time of such publication; and said section 1 shall be published, as aforesaid, once in each and every week continuously in said paper until said 1st day of June, 1881, and in case in the mean time any one of said papers shall cease to be published, then such publication shall be made in some other paper in same county (if any), and on conclusion of such publication such publisher of such paper shall deliver to the secretary of state his sworn certificate of publication in duplicate, showing that such publication has been made in his paper in compliance with the preceding section hereof, and stating the first and last day of such publication; and he shall thereupon be entitled to receive from the secretary of state a certificate of the amount due him for such

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publication, on presentation of which to the auditor of state he shall draw his warrant for the amount in favor of the holder on the State treasurer, who shall pay the same according to law. (Sec. 2, pp, 143, 144, Acts 1881, 1764.)

When at any time after the 1st day of June, A. D. 1881, any one or more persons, associations, or corporations, interested as owners of any ditch, canal, or reservoir in any water district shall present to the district court of any county having jurisdiction or priority of rights to the use of water for irrigation in such water district according to the provisions of (sec. 19, G. S., 1762) an act entitled "An act to regulate the use of water for irrigation and providing for settling the priority of rights thereto, and for payment of the expenses thereof, and for payment of all costs and expenses incident to said regulation of use, or to the judge thereof in vacation, a motion, petition, or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to use of water for irrigation between the several ditches, canals, and reservoirs in such district, the court, or judge thereof in vacation, shall, without unnecessary delay, in case he shall deem it practicable to proceed in open court, as prayed for, by an order to be entered of record upon such motion, petition or application, appoint a day in some regular or special term of said court for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court to proceed to hear all evidence which may be offered by or on behalf of any person, association, or corporation interested in any ditch, canal, or reservoir in such district, either as owner or consumer of water therefrom, in support of or against any claim or claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by any enlargement or extension thereof in such district, and consider all such evidence, together with any and all evidence, if any, which may have been heretofore offered and taken in such district in the same matter by any referee heretofore appointed under the provisions of said act above herein mentioned, and also the arguments of parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof as originally constructed, the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned, the time spent severally in such construction and enlargement, or extension and re-enlargement, if any, the diligence with which the work was in each case prosecuted, the nature of the work as to difficulty of construction, and all such other facts as may tend to show the compliance with the law, in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right, by appropriation of water, of the several ditches, canals, and reservoir [reservoirs] in such water district, concerning which testimony shall have been offered, each according to the time of its said construction and enlargement or enlargements or extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargements or extensions, describing such amount by cubic feet per second of time, if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir, in such decree. Said court shall further order that each and every party interested or claiming any such ditch, canal, or reservoir shall receive from the clerk, on payment of a reasonable fee therefor, to be fixed by the court, a certificate under seal of the court showing the date or dates and amount or amounts of appropriations adjudged in favor of such ditch, canal, or reservoir under and by virtue of the construction, extension, and enlargements thereof severally; also specifying the number of said ditch and of each priority to which the same may be entitled by reason of such construction, extension, and enlargements. (Sec. 4, pp.144–5–6, Acts 1881.)

The holder of such certificate shall exhibit the same to the water commissioner of the district when he commences the exercise of his duties, and as such water commissioner shall keep a book in which shall be entered a brief statement of the contents of such certificate, and which shall be delivered to his successor, and said certificate, or statement thereof in his book, shall be the warrant of authority to said water commissioner for regulating the flow of water in relation to such ditch, canal, or reservoir. Said certificate shall be recorded, at the same rates of charges as in cases of deeds of conveyance, in the records of each county into which the ditch, canal, or reservoir to which such certificate relates shall extend; and said certificate or said record thereof, or a duly certified copy of such record, shall be prima facie evidence of so much of said decree as shall be recited therein in any suit or proceeding in which the same may be relevant. (Sec. 5, pp. 146—7, Acts 1881, 1767.)

Notice shall be given by the clerk of said court of the time so appointed by publishing the same in one public newspaper in such county into which such water district may extend, which notice shall be so published in such paper once in each week until four successive weekly publications shall have been made, the last of which shall

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be on a day previous to the day appointed as aforesaid. Said notice shall contain a copy of said order, and shall notify all persons, associations, and corporations interested as owners in any ditch, canal, or reservoir in such water district to appear at said court at the time so appointed and file a statement of claim under oath, in case no statement has been before filed by him, her, or them, showing the ditch, canal, or reservoir, or two or more such, in which he, she, or they claim an interest, together with the names of all the owners thereof, which statement may be made by any one of the owners of such ditch, canal, or reservoir for and in behalf of all; and also that all persons interested as owners or consumers may then and there present his, her, or their proofs for or against any priority of right of water by appropriation sought to be shown by any party by or through any such ditch, canal, or reservoir (either as owner or consumer of water drawn therefrom). Ten printed copies of said notice shall also be posted in ten public places in such water district not less than twenty days before the day so appointed, which copies shall be so posted by the party or parties moving the adjudication. (Sec. 6, p. 147, Acts 1881, 1768.)

Proof of the proper publication of said notice or notices in said public papers shall consist in such case of the sworn certificate of the publisher of such newspaper, showing the publication to have been made in accordance with the provisions of section 3, of this act, which certificate shall be procured by the party or parties moving the adjudication at his or their expense, and on said certificate being filed the clerk shall enter the amount of the printer's fee therefor as costs advanced by the party procuring the same, which sum shall be counted to his, her, or their credit in distribution of cost. Proof of the posting of said printed copies shall be made by the affidavit of some credible person, certified to be such by the clerk or other officer administering the oath, showing when, where, and how said copies were posted. (Sec. 7, pp. 147-8, Acts 1881, 1769.)

The party or parties moving such adjudication shall cause a printed or written copy of the notice aforesaid, published as aforesaid, to be served on every person, association, or corporation shown by the statement of claim on file, as provided in section 1 hereof, which service shall be made within ten days from the time of the first publication by the clerk, by any credible person certified by said clerk or referee to be such, by delivering such copy as aforesaid to the person to be served, if such person by due diligence can be found in the county of his residence. If such person can not be found, as aforesaid, then by leaving such copy at his or her usual place of residence, if he or she have such residence, in charge of some person of the age of fourteen years or over there residing; and on any corporation by delivering the copy to the president, or vice-president, or secretary, or treasurer thereof, or the manager or superintendent in charge of their ditch, canal, or reservoir, or authorized agent or attorney, or by leaving such copy at the office or usual place of business of such corporation, and the proof of such service shall be made by affidavit of the person or persons serving said copies, showing when and how such service has been made on such party. In case of parties not served in any manner as aforesaid the clerk shall deposit in the post-office, duly inclosed in an envelope with the proper postage stamp thereon, a copy directed to the address of such party, shown in the statement of claim aforesaid, filed by him or her under section 1 hereof. (Sec. 8, pp. 148-9, Acts 1881, 1770.)

The court, in making such decree, as aforesaid, shall number the several ditches and canals in the water district concerning which adjudication is made in consecutive order, according to priority of appropriation of water thereby made by the original construction thereof, as near as may be, having reference to the date of each decree as rendered, and shall also number the reservoirs in like manner separately from ditches and canals, and shall further number each several appropriation of water consecutively, beginning with the oldest appropriation, without respect to the ditches or reservoirs by means of which such appropriations were made; whether such appropriation shall have been made by means of construction, extension, or enlargement, which number of each ditch, canal, or reservoir, together with the number or numbers of any appropriations of water held to have been made by means of the construction, extension or enlargement thereof, shall be incorporated in said decree and certificate of the clerk, to be issued to the claimants, as provided in section 1 of this act, so as to show the order in priority of such ditch or canal; and of such reservoir, and also of such successive appropriation of water pertaining thereto, for the information of the water commissioner of the district in distributing water, such numbering to be as near as may be having reference to date of decrees as rendered. (Sec. 9, p. 149, Acts 1881, 1771.)

If for any cause the judge of said court shall deem it impracticable or inexpedient to proceed to hear such evidence in open court, he shall, instead of the order mentioned in section 4 of this act, make and cause to be entered of record an order appointing some discreet person, properly qualified, a referee of said court, to whom shall be referred the statement of claim aforesaid on file in said matter, the matter of taking evidence and reporting the same, making an abstract and findings upon the

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same, and preparing a decree in said adjudication; and also in case of any water district in which a referee has been heretofore appointed, and evidence taken by him under the provisions of the act, the title of which is recited in section 4 of this act; such evidence so already taken, together with the abstract thereof and report of the referee who took the same, shall be also referred to said referee, to be appointed as aforesaid, and he shall proceed with his duties as hereinafter provided, first taking an oath [of] office, such as is required to be taken by referees in other cases under the provisions of the code of civil procedure. (Sec. 10, pp. 149–50, Acts 1881,1772.)

Said referee shall prepare and publish a notice containing a copy of the order appointing him, in which notice he shall appoint a time or times and place or places suitable and convenient for the claimants in such water districts at which he will attend for the purpose of hearing and taking evidence touching the priority of right of the several ditches, canals, and reservoirs in said district, and notifying all persons, associations, and corporations interested as owners or consumers of waters [water] to attend by themselves, their agents, or attorneys, at the times and places appointed in said notice, and notifying such owners to then and there file a statement of claim in case such statement has not been already filed under the provisions of section 1 hereof, such as mentioned in section 6 hereof, and present their proofs touching any priority of right claimed by them for any ditch, canal, or reservoir in said district, which notice shall be published in same manner and times and in all respects according to the provisions for publication of the newspaper notices mentioned in section 6 of this act, and proof of such publication shall be made in the same manner as is provided in section 7 of this act; and he shall also post ten or more printed copies of such notice in ten or more public places in said district, which copies shall be so posted at least twenty days before the time of commencing to take said evidence. (Sec. 11, p. 150, Acts 1881, 1773.)

Proof of the posting of said copies shall be made by the affidavit of said referee or other person certified by him to be a credible witness, which shall show when, where, and how the said copies were posted, and shall be filed by him with his report. (Sec. 12, p. 151, Acts 1881.)

Said referee shall attend at the times and places mentioned in his said notice, for the purpose therein mentioned; and all persons, associations, choosing to do so, and being interested as owners of or consumers of water from any ditch, canal, or reservoir in said district, and may also attend by themselves, their agents or attorneys, before said referee, at some one or more of said times and places so appointed, and shall have right to offer any and all evidence they may think advisable for their interests in the matter to be adjudicated, as well in districts in which evidence has been heretofore taken as in other districts. All such evidence as has been heretofore taken, if any, in such district, shall be kept present by said referee, subject to inspection by any party desiring to examine the same for purposes of the investigation. (Sec. 13, p. 151, Acts 1881, 1775.)

Said referee shall have power to administer oaths to all witnesses, and to issue subpœnas for witnesses and subpœnas *duces tecum*, which subpœnas may be served by any party, or constable, or sheriff, or deputy sheriff, and may require witnesses to appear at any of the places appointed by said referee for taking evidence. He shall permit all witnesses to be examined by the parties calling them respectively, and to be cross-examined by any party interested, and he shall take all testimony in writing, and note all objections offered to any part of the testimony taken, with the cause assigned for the objection, and shall proceed in all other respects as in case of taking depositions. He shall certify all books and papers offered by any one in his own behalf, and preserve them with the testimony offered concerning the same, and in case of books and papers offered in evidence, which shall not be under the control of the party desiring the evidence for which such books may be offered, said referee shall make a true copy of the parts demanded and certify the same, and preserve the same, together with the evidence offered concerning the same and concerning said books and papers, as part of the evidence in the matter. (Sec. 14, pp. 151–2, Acts 1881, 1776.)

No person, association, or corporation willfully refusing to produce any book or paper, if in his or their power to do so, when rightfully demanded for examination and copying, shall be allowed the benefit of any testimony or proofs in his, her, or their behalf, in making final adjudication, if the court shall be satisfied, from all the evidence shown concerning such refusal, that the same was willful. (Sec. 15, p. 152, Acts 1881, 1777.)

Said referee shall also examine all witnesses to his own satisfaction, touching any point involved in the matter in question, and shall ascertain as far as possible the date of the commencement of each ditch, canal, or reservoir, with the original size and carrying capacity thereof, the time of the commencement of each enlargement thereof, with the increased carrying capacity thereby occasioned, the length of time spent in such construction or enlargement, the diligence with which the work was prosecuted, the nature of the work as to difficulty of construction, and all such other facts as may tend to show compliance with the law in acquiring the priority of right

claimed for such ditch, canal, or reservoir; and upon all the facts so obtained shall be determined the relative priorities among the several ditches, canals, and reservoirs, the volume or amount of water lawfully appropriated by each, as well as by means of the construction, as by the enlargements thereof, and the time when each such several appropriations took effect. (Sec. 16, p. 152, Acts 1881, 1778.)

Every person present before said referee at any time when he shall be engaged in hearing testimony, who shall willfully disturb the proceedings; and every person who shall willfully refuse or neglect to obey the subpœna issued by said referee, when his lawful fees shall be tendered him for his attendance before the referee, shall be guilty of contempt of the court appointing such referee, and on complaint, under oath of the referee or other person, before the said district court, or judge thereof in vacation, may be brought before the court or judge and dealt with accordingly. (Sec. 17, pp. 152-3, Acts 1881, 1779.)

Every witness who shall attend before said referee under subpœna, by request of any party, shall be entitled to the same fees and mileage as witnesses before the district court in the county in which he shall so attend, and shall be paid by the party requiring his testimony. (Sec. 18, p. 153, Acts 1881, 1780.)

The said referee shall take all the testimony offered, and for that purpose shall give reasonable opportunity to all parties to be heard, and may at any place, when the time limited thereat shall expire, adjourn the further taking of testimony then proposed or desired to be offered to the next place in order according to his said published appointments, and at the last place may continue until all testimony shall be taken or make further appointments at any former place or places as may seem best and most convenient for all parties, giving reasonable notice thereof. (Sec. 19, p. 153, Acts 1881, 1781.)

Said referee, upon closing the testimony, shall proceed to carefully examine the same, together with all testimony and proofs which may have been heretofore taken by any former referee in the same district, if any such shall have been taken under the provisions of said act, the title of which is recited in section 4 of this act; he shall make an abstract of all the testimony and proofs in his possession concerning each ditch, canal, and reservoir separately, and shall number each ditch and canal in order, and likewise each reservoir, each class consecutively, and also number the several appropriations of water shown by the evidence, all in manner and form as provided in section 9 hereof, and shall make a separate finding of all the facts connected with each ditch, canal, and reservoir, touching which evidence shall have been offered; and he shall prepare a draught of a decree in accordance with his said findings, in substance the same as the decree mentioned in section 4 of this act, and conformable also to the provisions of section 9 hereof, so far as the same are applicable, which decree, so prepared by him, shall be returned with his report to the court, and he shall file his report with said evidence, abstract, and findings, and said decree, with the clerk of the court, and inform the judge of so doing without delay. (Sec. 20, pp. 153-4, Acts 1881, 1782.)

Upon the filing of said report the court, or judge thereof in vacation, shall cause an order to be entered setting some day in a regular or special term of said court as soon as practicable, when the court will proceed to hear and determine the report, at which time any party interested may appear, himself or counsel, and move exceptions to any matter in the findings or decree made by said referee, and after hearing the same the court shall, if the decree reported be approved, cause the same to be entered of record, or otherwise such modifications thereof, or other decree as shall be found just and conformable to the evidence and the true intent of this act, and to so much of any and all former laws of the State as shall be adjudged consistent herewith. (Sec. 21, p. 154, Acts 1881, 1783.)

No claim of priority of any person, association, or corporation, on account of any ditch, canal, or reservoir, as to which he, or she, or they, shall have failed or refused to offer evidence under any adjudication herein provided for, or heretofore provided by this act, the title of which is recited in section 4 hereof, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have by application to the court having jurisdiction obtained leave and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which leave shall be granted in all cases upon terms as to notice to other parties interested, and on payment of all costs, and upon affidavits or petition sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof against which such priority is claimed, nor until a decree adjudging such priority to such ditch, canal, or reservoir has been entered, and certificate, such as mentioned in section 4 hereof, shall have been issued to claimant and presented to the water commissioner. (Sec. 22, pp. 154-5, Acts 1881, 1784.)

Every party interested shall have the right to complain to the court of any act of willful neglect or oppression on the part of the said referee in exercising his powers under this act, whereby such party shall have been aggrieved, either by refusal of

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said referee to hear or take evidence offered, or by preventing reasonable opportunity to offer such evidence; and the court may order such proceedings in the premises as will give redress of the grievance, at the cost of said referee, if he appear willfully in fault; otherwise, in case of accident or mistake, costs shall be awarded as to the court shall seem just. (Sec. 23, p. 155, Acts 1881, 1785.)

The district court, or judge thereof in vacation, shall have power to make all orders and rules consistent with this act which may be found necessary and expedient, from time to time during the progress of this case, for carrying out the intent of this act, and of all parts consistent therewith of the said act, the title of which is recited in section 4 hereof; as well as touching the proceedings in court, as of the acts and doings of said referee, for the purpose of securing to any party aggrieved by the acts of said referee or any proceeding of the court, opportunity for redress; and this act shall be construed liberally in all courts, in favor of securing to all persons interested the just determination and protection of their rights. (Sec. 24, p. 155, Acts 1881, 1786.)

No persons, associations, or corporation representing any ditch, canal, or reservoir, shall be permitted to give or offer any evidence before said referee until he, she, or they shall have filed a statement of claim in substance the same in all respects as is required to be filed under the provisions of section 1 hereof. (Sec. 25, p. 155, Acts 1881, 1787.)

The district court, or judge thereof in vacation, shall have power to order, for good cause shown, and upon terms just to all parties, and in such a manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this act, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved, that the ends of justice will be thereby promoted; but no such review or re-argument shall be ordered unless applied for by petition or otherwise within two years from the time of entering the decree complained of. (Sec. 26, p. 156, Acts 1881, 1788.)

Any party or parties representing any ditch, canal or reservoir, or any number of parties representing two or more ditches, canals, or reservoirs, which are affected in common with each other by any portion of such decree, by which he or she or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining, desiring an appeal, shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common adversely to the interests of appellants shall be the appellees. The party or parties joining in such appeal shall file a statement in writing, verified by affidavit properly entitled in such cause in the district court, which statement shall show that the appellants claim a valuable interest in the ditch, canal, or reservoir, or two or more of such, which are affected in common with each other by some portion of said decree; also stating the name or names, or otherwise the description of the same, and the name or names, or otherwise the description of any one or more other ditches, canals [or] reservoirs, which by said decree derive undue advantage in respect of priority as against that or those represented by appellants; and also setting forth the name or names, of the party or parties claiming such other one or more ditches, canals or reservoirs, affected in common by said decree adversely to the interest of appellant or appellants, and praying that an appeal be allowed against such other parties as appellees. If the court or judge in vacation, on examination, find such statement in accordance with the statements of claim filed by the parties named as appellees, mentioned in section 1 of this act, he shall approve the same and make an order to be prepared and presented by the appellants allowing the appeal and showing the name or names of the appellants and appellees, with the name or names or description of the one or more ditches, canals, or reservoirs claimed by the party or parties appellant and appellee, as shown by their several statements of claim filed as aforesaid, before the taking of testimony, and fix the amount of the appeal bond, which bond shall be executed by one or more of appellants, as principal or principals, and by sufficient securities, and approved by the court or judge in vacation, and shall be conditioned for the payment of all costs which may be awarded against the appellants or any of them in the supreme court. (Sec. 27, pp. 156–157, Acts 1881, 1789.)

The order last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the appellees, by delivering the same to him or her, if he or she may be found, or otherwise serving the same in manner the same as may be at the time provided for serving summons from the district court by the laws then in force, and shall also cause the said order to be published in the same manner as the notices required to be published by the referee mentioned in section 11 of this act, and proof of the publication in any newspaper shall be the same as in case of said referee's notice, and proof of the posting of the ten printed copies in the district shall be by affidavit of the parties posting the same, with the certificate of the clerk of the district court appealed from, that the affiant is a known and credible person. (Sec. 28, p. 157, Acts 1881, 1790.)

The appellant or appellants shall file the transcript or record of the district court

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with the clerk of the supreme court at any time within six months after the appeal shall be allowed as aforesaid. Only so much of the decree appealed from, and so much of the evidence as shall affect the appropriations of water claimed by means of the construction or enlargement or re-enlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal, need be copied into the bill of exceptions. (Sec. 29, pp. 157–158, Acts 1881, 1791.)

The supreme court, on dismissal of such appeal, or on affirming or reversing the parts of the decree appealed from, in whole or in part, shall award costs, as in its discretion shall be found and held to be equitable. (Sec. 30, p. 158, Acts 1881, 1792.)

The supreme court, in all cases in which judgment is rendered, and any part of the decree appealed from is reversed, and in which it may be practicable, shall make such decree in the matters involved in the appeal as should have been made by the district court, or direct in what manner the decree of that court should be amended. (Sec. 31, p. 158, Acts 1881, 1793.)

The said proof of the service and publication of said order allowing the appeal shall be filed with the clerk of the supreme court within sixty days after the making of said order, and if not so filed the supreme court shall, on motion of the appellee or any of the appellees, at any time after such default in filing said proof, and before the said proof shall be filed, dismiss such appeal, and if the transcript of record be not filed within the time limited by section 29 of this act, such appeal shall, on motion, be dismissed. After the filing of the record and proof of service aforesaid the cause on appeal shall be proceeded with as the rules of the supreme court, or such special rules as said court may make in such cases, and their order from time to time thereunder may require. Said court shall have power to make any and all such rules concerning such appeals as may be necessary and expedient in furtherance of this act, as well as to preparation of the case for submission as to supplying deficiencies of record, if any, and for avoiding unnecessary costs and delay. (Sec. 32, p. 158, Acts 1881, 1794.)

The district court, or judge thereof in vacation, in case of the death, resignation, illness, absence, or other disability of the referee hereby provided for, or for any misconduct in him, or other good cause to such judge appearing, shall appoint such other properly qualified person in his stead as he shall deem proper, who shall proceed without delay to perform all the duties of his office, as herein pointed out, which shall remain unperformed by his predecessor in office. (Sec. 33, p. 159, Acts 1881, 1795.)

Nothing in this act or in any decree rendered under the provisions thereof, shall prevent any person, association or corporation from bringing and maintaining any suit or action whatsoever hitherto allowed in any court having jurisdiction to determine any claim of priority of right to water, by appropriation thereof, for irrigation or other purposes, at any time within four years after the rendering of a final decree under this act in the water district in which such rights may be claimed, save that no writ of injunction shall issue in any case restraining the use of water for irrigation in any water district wherein such final decree shall have been rendered, which shall effect [affect] the distribution or use of water in any manner adversely to the rights determined and established by and under such decree, but injunctious may issue to restrain the use of any water in such disirict not affected by such decree, and restrain violations of any right thereby established, and the water commissioner of every district where such decree shall have been rendered shall continue to distribute water according to the rights of priority determined by such decree, notwithstanding any suits concerning water rights in such district, until in any suit between parties the priorities between them may be otherwise determined, and such water commissioner have official notice by order of the court or judge determining such priorities, which notice shall be in such form and so given as the said judge shall order. (Sec. 34, p. 159, Acts 1881, 1796.)

After the lapse of four years from the time of rendering a final decree in any water district, all parties whose interests are thereby affected shall be deemed and held to have acquiesced in the same, except in case of suits before then brought, and thereafter all persons shall be forever barred from setting up any claim to priority of rights to water for irrigation in such water district adverse or contrary to the effect of such decree. (Sec. 35, p. 160, Acts 1881, 1797.)

The referee appointed [as provided] in this act shall be paid the sum of $6 per day while engaged in discharging his duties as herein provided, and also his reasonable and necessary expenses and mileage at the rate of 10 cents for each mile actually and necessarily traveled by him in going and coming in the discharge of his duties as such referee, which said per diem allowance, expenses, and mileage shall be paid out of the treasury of the county in which such water district shall lie, if it be contained in one county, and if such water district shall extend into two or more counties, then in equal parts thereof, shall be paid out of the treasury of such county into which such district shall extend. He shall keep a just and true account of his services, expenses, and mileage, and present the same from time to time to the district court, or

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judge in vacation, verifying the same by oath, and the judge, if he finds the same correct and just, shall certify his approval thereof thereon, and the same shall thereupon be allowed by the board of county commissioners of the county in which said water district shall lie, but if said [water district] extend into two or more counties, he shall receive from the clerk of the district court separate certificates under seal of the court, showing the amount due him from each county, upon which certificate the board of county commissioners of the respective counties shall allow the same on presentation thereof. (Sec. 36, p. 160, Acts 1881, 1798.

All laws and parts of laws heretofore in existence inconsistent with the provisions of this act, shall be and the same are hereby appealed. (Sec. 37, p. 160, Acts 1881, 1799.

Nothing herein contained shall be construed to authorize any sheriff to serve any writ outside the limits of his own county, or give effect to any record by way of notice or otherwise, in any county other than that in which it belongs. (Sec. 35, p. 106, Acts 1889, 1800.)

The fees of the clerk of the district court for a service rendered under this act shall be paid by the counties interested in the same manner as the fees of the water commissioners, upon the said clerk rendering his account, certified by the district judge, to the board or boards of county commissioners of said county or counties embracing the water district in case of which the services shall have been rendered. (Sec. 43, p. 108, Acts 1879, 1801.)

Whenever testimony shall or may be taken in any district created by this act for the purpose of procuring a decree as to appropriation of water and priorities thereof, under the statutes of this State, any testimony theretofore taken before any former referee may be introduced, and shall be received as evidence. (Sec. 28, p. 259.)

Any ditch company formed under the provisions of this (corporations) act shall have the right of way over the line named in the certificate. (Sec. 275 (85), p. 171, G. L., 309.)

When any person owning claims in such locality (on the bank, margin, or neighborhood of any stream) has not sufficient length of area exposed to said stream to obtain a sufficient fall of water to irrigate his land, or that his farm or land used by him for agricultural purposes is too far removed from said stream, and that he has no water facilities on those lands, he shall be entitled to a right of way through the farms or tracts of lands which lie between him and said stream, or the farms or tracts of lands which lie above or below him on said stream, for the purposes hereinbefore stated. (Sec. 2, p. 67, acts 1861. Sec. 2, p. 362, R. S. Sec. 1373 (2), p, 515, G. L., 1712.)

Such right of way shall extend only to a ditch, dike, or cutting sufficient for the purpose required. (Sec. 3, p. 67, acts 1861. Sec. 3, p. 363, R. S. Sec. 1734 (3), p. 115, G. L., 1713.)

Upon the refusal of the owners of tracts of land or lands through which said ditch is proposed to run to allow of its passage through their property the person or persons desiring to open such ditch may proceed to condemn and take the right of way therefor (under the provisions of the "eminent domain act"). (Sec. 1376 (5), p. 516, G. L., 1715.)

No tract or parcel of improved or occupied land in this State shall, without the written consent of the owner thereof, be subjected to the burden of two or more irrigating ditches constructed for the purpose of conveying water through said property to lands adjoining or beyond the same when the same object can feasibly and practicably be attained by uniting and conveying all the water necessary to be conveyed through such property in one ditch. (Sec. 1, p. 164, acts 1881, 1716.)

Whenever any person or persons find it necessary to convey water for the purpose of irrigation through the improved or occupied lands of another, he or they shall select for the line of such ditch through such property the shortest and most direct route practicable upon which said ditch can be constructed with uniform or nearly uniform grade and discharge the water at a point where it can be conveyed to and used upon the land or lands of the person or persons constructing such ditch. (Sec. 2, p. 164, acts 1881, 1717.)

No person or persons having constructed a private ditch for the purposes and in the manner hereinafter provided shall prohibit or prevent any other person or persons from enlarging or using any ditch by him or them constructed in common with him or them upon payment to him or them of a reasonable proportion of the costs of construction of said ditch. (Sec. 3, p. 164, acts 1881, eminent domain, 1718.)

The right of way shall not be refused by the owner of any tract of land upon which it is required (by those who wish to place wheels upon the bank of a stream), subject, of course, to the like regulations as required for ditches, and laid down in sections hereinbefore enumerated. (Sec. 8, pp. 68–9, acts 1861. Sec. 6, p. 364, R. S. Sec. 1377 (6), p. 516, G. L., 1727.)

If any corporation formed under this (corporations) act for the purpose of constructing a * * * ditch * * * shall be unable to agree with the owner for the purchase of any real estate required for the purposes of any such corporation or company,

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r the transaction of the business of the same, or for right of way, or any other lawful purpose connected with or necessary to the operations of such company, such corporations may acquire such title in the manner provided by law. (Sec. 304 (114), p. 182, G. L., 338.)

Any company formed under the provisions of this act for the purpose of constructing a * * * ditch * * * may cause such examination and survey as may be necessary to the selection of the most advantageous route, and for such purpose, by its officers, agents, or servants, may enter upon the lands of any person or corporation, but subject to liability for all actual damages which shall be occasioned thereby. (Sec. 305 (115), p. 183, G. L., 339.)

Persons desirous to construct and maintain reservoirs for the purpose of storing water shall have the right to take from any of the natural streams of the State and store away any unappropriated water not needed for immediate use for domestic or irrigating purposes; to construct and maintain ditches for carrying such water to and from such reservoir, and to condemn lands for such reservoirs and ditches in the same manner provided by law for the condemnation of lands for right of way for ditches: *Provided,* No reservoir with embankments or a dam exceeding ten feet in height shall be made without first submitting the plans thereof to the county commissioners of the county in which it is situated and obtaining their approval of such plans. (Sec. 38, pp. 106–7, acts 1879, 1724.)

The owners of any reservoir may conduct the water therefrom into and along any of the natural streams of the State, but not so as to raise the waters thereof above ordinary high-water mark, and may take the same out again at any point desired without regard to the prior rights of others to water from said stream; but due allowance shall be made for evaporation and seepage, the amount to be determined by the commissioners of irrigation of the district; or, if there are no such commissioners, then by the county commissioners of the county in which the water shall be taken out for use. (Sec. 39, p. 107, acts 1879, 1725.)

The owners of the reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by breaking of the embankments of such reservoirs. (Sec. 40, p. 107, acts 1879, 1726.)

Every ditch company organized under the provisions of this (corporations) act shall be required to keep their ditch in good condition, so that the water shall not be allowed to escape from the same to the injury of any mining claim, road, ditch, or other property; and whenever it is necessary to convey and ditch over, across, or above any lode or mining claims or to keep the water so conveyed therefrom, the company shall, if necessary to keep the water of said ditch out or from any claim, flume the ditch so far as necessary to protect such claim or property from the water of said ditch. (Sec. 278 (88), pp. 172–3, G. L., 312.)

The owners of reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by the breaking of the embankments of such reservoirs. (Sec. 40, p. 107, acts 1879, 1726.)

The owner or owners of any ditch for irrigation or other purposes shall carefully maintain the embankments thereof, so that the waters of such ditch may not flood or damage the premises of others, and shall make a tail ditch so as to return the water in such ditch with as little waste as possible into the stream from which it was taken. (Sec. 7, p. 36, R. S., with first clause, amendment, 1872, p. 144, sec. 1, second clause, sup. by sec. 2, p. 78, acts 1876, 1728.)

Any ditch company constructing a ditch, or any individual having ditches for irrigation, or for other purposes, wherever the same may be taken across any public highway or public traveled road, shall put a good substantial bridge, not less than 14 feet in breadth, over such water-course where it crosses said road. (Sec. 10, p. 364, R. S. Sec. 1381 (10), p. 516, G. L., 1730.)

When any such ditch or water-course shall be constructed across any public traveled road, and not bridged within three days thereafter, it shall be the duty of the supervisor of the road district to put a bridge over said ditch or water-course, of the dimensions specified in section 10 of this chapter, and call on the owner or owners of the ditch to pay the expenses of constructing such bridge. (Sec. 11, p. 364, R. S. Sec. 1382 (21), p. 517, G. L., 1731.)

If the owner or owners of such ditch refuse to pay the bill of expenses so presented, the supervisor may go before any justice of the peace in the township or precinct and make oath to the correctness of the bill, and that the owner or owners of the ditch refuse payment; and thereupon such justice of the peace shall issue a summons against such owner or owners, requiring him or them to appear and answer to the complaint of such supervisor in an action of debt for the amount sworn to be due, such summons to be made returnable and served, and proceedings to be had thereon as in other cases; and in case judgment shall be given against such owner or owners the justice shall assess, in addition to the amount sworn to be due as aforesaid, the sum of $10 as damages arising from the delay of such owner or owners, such judgment to be collected as in other cases, and to be a fund in the hands of the supervisor

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of roads for the repairs of roads in such precinct or district. (Sec. 12, p. 365, R. S. Sec. 1383 (12), p. 517, G. L., 1732.)

No person or persons, or corporation * * * shall cause waste water, or the water from any ditch, road, drain, or flume or other place, to flow in or upon any road or highway so as to damage the same, and any such person or persons or corporation so offending or violating any of the provisions of this section or any of the sections of this act, for which there is no specific penalty provided, shall pay a fine of not less than $10 nor more than $300 for each offense, and a like fine of $10 for each day that such obstruction shall be suffered to remain in said highway, and shall also be liable to any person or persons or corporation in a civil action for any damages resulting therefrom; and it shall be the duty of the road overseer in the district in which such violation shall occur to prosecute any person, persons, corporation, or corporations violating the provisions of this act. (As amended, p. 326, Session Laws, 1885, 2988.)

Any person or persons, corporation or company, owning or constructing any ditch, race, drain, or flume, in, upon, or across any highway, shall keep the highway open for safe and convenient travel by constructing bridges over such ditch, race, drain, or flume; and within five days after any ditch is constructed across, in, or upon any highway at any point thereof so as to interfere with or obstruct such highway, the person or persons owning or constructing such ditch shall erect a good and substantial bridge of not less than 20 feet in width across the same, which shall thereafter be maintained by the county: *Provided*, That all such bridges which shall be of greater length than 20 feet, shall be constructed as herein provided, and thereafter maintained in proper condition for safe travel by the owner or owners of said ditch. Any person or persons, corporation or company, constructing any ditch, race, drain, or flume, in, upon or across any highway, and failing to keep the highway open for safe and convenient travel, as in this act provided, shall forfeit the sum of $25 to the county for each and every day of failure to keep the same open for safe and convenient travel as aforesaid. And any person or persons, corporation or company, who shall fail to erect a good and substantial bridge across any ditch, race, drain, or flume, within five days after the same is constructed in, upon, or across any highway, and keep the same in proper condition and repair, as herein provided, shall forfeit the sum of $25 to the county for each and every day of failure to erect such bridge and keep the same in repair, as aforesaid, together with the cost of constructing there a good and substantial bridge, or making necessary repairs, which the road overseers of the district shall at once proceed to build or repair, and such party or parties so neglecting shall also be liable in damages to any person or persons damaged by such neglect. (As amended, session laws, 1885, p. 324, 2990.)

The owner of any irrigating or mill ditch shall carefully maintain and keep the embankments thereof in good repair, and prevent the water from wasting. (Sec. 1, p. 78, acts 1876. Sec. 1385 (1), p. 518, G. L., 1733.)

During the summer season it shall not be lawful for any person or persons to run through his or their irrigating ditch any greater quantity of water than is absolutely necessary for irrigating his or their said land, and for domestic and stock purposes; it being the intent and meaning of this section to prevent the wasting and useless discharge and running away of water. (Sec. 2, p. 78, Acts 1876. Sec. 1386 (2), p. 518, G. L., 1734.)

Any person who shall willfully violate any of the provisions of this act, shall, on conviction thereof before any court having competent jurisdiction, be fined in a sum of not less than $100. Suits for penalties under this act shall be brought in the name of the people of the State of Colorado. (Sec. 3, p. 78, Acts 1876. Sec. 1387 (3), p. 518, G. L., 1735.)

That the owner or owners of every irrigating ditch, flume or canal, in this State shall be required to erect and keep in good repair a head-gate at the head of their ditch, flume, or canal. Such head-gate, together with the necessary embankments, shall be of sufficient height and strength to control the water at all ordinary stages.

The frame-work of such head-gate shall be constructed of timber not less than 4 inches square, and the bottom, sides, and gate, or gates, shall be of plank not less than 2 inches in thickness. (Sec. 1, p. 165, Acts 1881, 1736.)

Owners of all ditches shall be liable for all damages resulting from their neglect or refusal to comply with the provisions of section 1 (G. S. 1736) of this act. (Sec. 2, p. 165, Acts 1881, 1737.)

Ditch owners are also required to construct and maintain a weir, or measuring device at the heads of their ditches. (Ch. XIV.)

Every person who shall willfully open, close, change, or interfere with any head-gate or water-box, without authority, shall be guilty of a misdemeanor, and on conviction thereof shall be fined not less than $50, nor more than $300, and may be imprisoned not exceeding sixty days. (Sec. 44, p. 108 Acts 1879, 1755.)

Any person or persons who shall knowingly and willfully cut, dig, break down, or open any gate, bank, embankment, or side of any ditch, canal, flume, feeder, or reservoir in which such person or persons may be joint owner, or the property of another,

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or in the lawful possession of another or others, and used for the purpose of irrigation, manufacturing, mining, or domestic purposes with intent maliciously to injure any person, association, or corporation, or for his or her own gain, unlawfully, with intent of stealing, taking or causing to run or pour out of such ditch, canal, reservoir, feeder, or flume, any water for his or her own profit, benefit, or advantage, to the injury of any other person, persons, associations, or corporation, lawfully in the use of such water or of such ditch, canal, reservoir, feeder, or flume, he, she or they so offending shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not less than $5 nor more than $300, and may be imprisoned in the county jail not exceeding ninety days. (Sec. 1, p. 163, Acts 1881, 1759.)

Justices of the peace shall have jurisdiction of all offenses under the provisions of this act (G. S. 1759), saving to any party defendant the right to be tried by a jury, as in other criminal cases before such justices now provided for by law; and also the right to appeal, in manner and form as by law now, or hereafter to be provided for by law, in criminal cases before such justices. (Sec. 2, p. 163, Acts 1881, 1760.)

Every person who shall willfully commit any trespass by entering upon the improved or inclosed land of another, without the permission of the owner thereof, with intent to cut, injure, or destroy any dam, dike, or embankment kept or maintained for the purpose of storing water in any lake, creek, or reservoir, shall, upon conviction therefor, be punished by imprisonment in the county jail not less than ten days nor more than one year, or by a fine of not less than $50 and not more than $1,000, or by both such fine and imprisonment. (P. 165.)

If any person shall unlawfully, wantonly, willfully, or maliciously, cut down, break down, level, demolish, or otherwise destroy or damage any bridge, embankment, mill-dam, or ditch, being the property of another * * * where the value of the personal property destroyed or injured shall exceed $20, shall, on conviction, be punished by imprisonment in the State penitentiary not more than five years, or by a fine not exceeding $1,000; or, where the value of the personal property destroyed or injured shall be $20 or under, shall, on conviction, be punished by a fine not exceeding $100, or imprisonment in the county jail not more than three months, or both such fine and imprisonment in the discretion of the court. (As amended Session Laws 1885, p. 167, 903.)

Any person who shall willfully or maliciouly damage or interfere with any * * * ditch, flume, * * * or any of the fixtures, tools, implements, appurtenances, or any property of any company which may be organized under the provisions of this act, upon conviction thereof before any court of competent jurisdiction in the county where the offense shall have been committed, shall be deemed guilty of a misdemeanor, and shall be punished by fine or imprisonment, or both, at the discretion of the court, said imprisonment not to exceed one year, and said fine not to exceed $500, which fine shall be paid into the county treasury for the use of the common schools, and said offender shall also pay all damages that any such corporation may sustain, together with costs of suit. (Sec. 297 (107), p. 180, G. L., 315.)

If any person or persons shall hereafter throw or discharge into any stream of running water, or into any ditch or flume in this State, any obnoxious substance, such as refuse matter from slaughter-house or privy, or slops from eating-houses or saloons, or any other fleshy or vegetable matter which is subject to decay in the water, such person or persons shall, upon conviction thereof, be punished by a fine not less than $100 nor more than $500 for each and every offense so committed. (Sec. 1, Acts 1874, p. 99. Sec. 165, p. 307, G. L. In force Feb. 13, 1874, 882.)

That it shall be lawful for any person or persons to float any and all kinds of timber, such as saw-logs, ties, fencing poles or posts, and fire-wood down any of the streams of this State: *Provided*, That any person or persons desiring to float any such timber down said streams shall first execute a bond running to the people of each county through which such timber is floated, in a sum sufficient to cover all damages that may be done to any bridges, dams, or irrigating ditches that are now or may hereafter be constructed in or across any streams of this State, such bond to be approved by the board of county commissioners of the county or counties through which such timber is to be floated. (Sec. 1856 (1), p. 643, G. L., 3259.)

Water sold by the inch by any individual or corporation shall be measured as follows, to wit: Every inch shall be considered equal to an inch square orifice under a 5-inch pressure, and a 5-inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water; said boxes, or any slot or aperture through which such water shall be measured, shall in all cases be 6 inches perpendicular, inside measurement, except boxes delivering less than 12 inches, which may be square, with or without slides. All slides for the same shall move horizontally, and not otherwise; and said box put into the banks of ditch shall have a descending grade from the water in ditch of not less than one-eighth of an inch to the foot. (Sec. 2779 (3), pp. 926–7, G. L. Sec. 6, p. 638, R. S. Amd. Sec. 1, pp. 308–9, Acts 1874 and 1877, 3472.)

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All persons for the purpose of weighing or measuring goods, wares, merchandise, water, or other articles actually sold by him, not in accordance with this chapter, hall be deemed guilty of a misdemeanor, and upon conviction thereof may be imprisoned not exceeding one year, or fined not exceeding $1,000, at the discretion of the court in which the conviction shall be obtained. (Sec. 2785 (9), p. 928, G. L. Sec. 9, p. 309, Acts 1874, 3478.)

Any company constructing a ditch under the provisions of this act shall furnish water to the class of persons using the water in the way named in the certificate, in the way the water is designated to be used, whether miners, mill men, farmers, or for domestic use, whenever they shall have water in their ditch unsold, and shall at all times give the preference to the use of water in said ditch to the class named in the certificate; the rates at which water shall be furnished to be fixed by the county commissioners as soon as such ditch shall be completed and prepared to furnish water. (Sec. 277 (87), p. 172, G. L., 211.)

The county commissioners of each county shall, at their regular January session in each year, hear and consider any and all applications which may be made to them by any party or parties interested in procuring water for irrigation by purchase from any ditch or reservoir furnishing and selling water, or proposing to furnish water for sale, the whole or upper part of which shall lie in such county, which application shall be supported by such affidavit or affidavits as the applicant may see proper to present, showing reasonable cause for such board to proceed to fix the price of water to be hereafter sold from such ditch or reservoir, and [if] such board of commissioners shall, upon examination of such affidavit or affidavits, or from the oaths of witnesses in addition thereto, find that the facts sworn to show the application to be in good faith, and that there is reasonable grounds to believe that unjust prices are, or are likely to be, charged for water from such ditch or reservoir, they shall enter an order fixing a day, not sooner than forty days thereafter nor later than the third day of the [next] regular session of their board, when they will hear all parties directly or indirectly interested in said ditch or reservoir, or in procuring water therefrom for irrigation, who may appear, as well as all the testimony by witnesses, or depositions taken on notices as hereinafter provided, touching the said ditch or reservoir, and the cost of furnishing water therefrom, at which time all persons or corporations interested in said ditch or reservoir, as well as all interested in obtaining water therefrom, or in lands which may be irrigated therefrom, may appear by themselves, their agents, or attorneys, and said commissioners shall then proceed to take action in the matter of fixing such price of water; provided the applicant shall, within ten days from the time of entering such order, cause a copy thereof, duly certified, to be delivered to the owner of such ditch or reservoir, if it be owned by one person, or each of the owners if it be owned by several persons, or to the president, secretary, or treasurer of the company if it belongs to a corporation or association having such officers, or if such owner can not be found he shall cause such copy to be left at his usual place of residence, with some person or member of his family residing there, and over fourteen years of age, and if such ditch officer can not be found, he shall cause such copy to be left at the office or place of business of the company of which he is such officer, or at his residence if such company have no place of business, and if such ditch is owned by several owners, not an incorporated company, it shall be sufficient to serve such notice by delivering one such copy each to a majority of them, and such applicant shall make affidavit of the manner in which such copy or copies have been served. Depositions mentioned in section 1 hereof, to be used before said commissioners, shall be taken before any officer in the State authorized by law to take depositions, upon reasonable notice being given to the opposite party of the time and place of taking such depositions. (Sec. 1, pp. 94-5-6, Acts 1879, 1738.)

Said board shall hear and examine all legal testimony or proofs offered by any of the parties interested, as before mentioned, as well concerning the value of the construction of such ditch and reservoir as the cost and expense of maintaining and operating the same, and all matters which may affect the just price and value of water to be furnished therefrom; and they shall have power to issue subpœnas to witnesses and compel their attendance, which subpœnas shall be served by the sheriff of the proper county when required; and also to compel the production of books and papers required for evidence in as full and ample a manner as the district court now has. They may adjourn the hearing from time to time to further the ends of justice or suit the general convenience of parties. Upon hearing an [and] considering all the matters and facts involved in the case, the board of commissioners shall enter an order naming and describing the ditch or reservoir with sufficient certainty, and fixing a just price upon all water to be thereafter sold, which price shall not be thereafter changed oftener than once in two years: *Provided*, That no price so fixed shall effect [affect] the rights of parties, or their lawful assignees or grantees, who may have contracts with the company, association, or person owning such ditch or reservoir, or their lessees, grantees, or successors, nor the rights of such owners, lessees, or grantees under such contract, nor shall it in any way affect or hinder the making of such contract. (Sec. 2, p. 96, Acts 1879, 1739.)

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Any person or persons, acting jointly or severally, who shall have purchased and used water for irrigation for lands occupied by him, her, or them, from any ditch or reservoir, and shall not have ceased to do so, for the purpose or with the intent to procure water from some other source of supply, shall have a right to continue to purchase water to the same amount for his, her, or their lands, on paying or tendering the price thereof fixed by the county commissioners as above provided; or, if no price shall have been fixed by them, the price at which the owners of such ditch or reservoir may be then selling water or did sell water during the then last preceeding year. This section shall not apply to the case of those who may have taken water as stockholders or share-holders after they shall have sold or forfeited their shares or stock, unless they shall have retained a right to procure such water by contract, agreement, or understanding, and use between themselves and the owners of such ditch, and not then to the injury of other purchasers of water from or shareholders in [the] same ditch. (Sec. 3, pp. 96, 97, Acts 1879, 1740.)

The lands now irrigated, or which may be hereafter irrigated, from ditches now taking water from the following-described rivers or natural streams of the State of Colorado, are hereby declared to constitute irrigation districts. (Sec. 5, p. 97, Acts 1879, 1741.)

Other irrigation districts may be formed from time to time by the governor on petition of parties interested. Several districts were formed under this power and commissioners appointed, and these new districts were incorporated into the new act. (Act 1879, creating districts.)

For the better regulation of the distribution of water for irrigation among the several ditches, canals, and reservoirs into which such water may be lawfully taken in times of scarcity thereof, the water districts now or to be hereafter established by law shall be constituted into water divisions, as follows: (Ditto), 1802.

There shall be one water commissioner for each of the above-named districts, and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioner so appointed shall hold his office until his successor is appointed and qualified. The governor shall, by like selection and appointment, fill all vacancies which may be occasioned by death, resignation, or continued absence from the district, removal or otherwise. Said county commissioners may, from time to time, recommend persons to be appointed as above provided, and the governor may at any time remove any water commissioner in his discretion. Sec. 16, pp. 98, 99, Acts 1879, 1752.)

That within ten days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe the oath of office prescribed by the constitution of this State. (Sec. 17, p. 99, Acts 1879, 1753.)

It shall be the duty of said water commissioners to divide the water in the natural stream or streams of their district among the several ditches taking water from the same, according to their prior rights of each respectively; in whole or in part to shut and fasten, or cause to be shut and fastened, by order given to any sworn assistant, sheriff, or constable of the county in which the head of such ditch is situated, the head-gate of any ditch or ditches heading in any of the natural streams of the district which in a time of a scarcity of water shall not be entitled to water by reason of the priority of the rights of others below them on the same stream. (Sec. 18, p. 99, Acts 1879, 1754.)

The water commissioners herein provided shall be each entitled to pay at the rate of $5 per day for each day he shall be actually employed in the duties of his office, not to exceed eighty days in any one year, to be paid by the county or counties in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of commissioners of the county in which his district may lie, and said board of commissioners shall allow the same; and if said irrigation district shall extend into two or more counties, then such water commissioner shall present his account for his said services, verified as aforesaid, to the board of county commissioners of each county into which such district extends, and each board of county commissioners shall allow an equal part thereof. (P. 254, Acts 1885, 1756.)

Said water commissioner shall have power, in case of emergency, to employ a suitable assistant to aid him in the discharge of his duties. Such assistant shall take the same oath as the water commissioner, and shall obey his instructions, and shall be entitled to $3 per day for every day he is so employed, not to exceed twenty-five days, to be paid upon the certificate of the water commissioner, in the same manner as provided for paying water commissioners. (Sec. 41, p. 107, Acts 1879, 1757.)

Said water commissioners shall not begin their work until they shall be called on by two or more owners or managers, or persons controlling ditches in their several

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districts, by application in writing, stating that there is necessity for their action; and they shall not continue performing services after the necessity therefor shall cease, 1758.

If at any time any ditch or reservoir from which water is or shall be drawn for irrigation shall not be entitled to a full supply of water from the natural stream which supplies the same, the water actually received into and carried by such ditch, or held in such reservoir, shall be divided among all the consumers of water from such ditch or reservoir, as well as the owners, share-holders or stockholders thereof as the parties purchasing water therefrom; and parties taking water partly under and by virtue of holding shares, and partly by purchasing the same, to each his share pro rata, according to the amount he, she, or they (in cases in which several consume water jointly) shall be then entitled, so that all owners and purchasers shall suffer from the deficiency arising from the cause aforesaid each in proportion to the amount of water which he, she, or they should have received in case no such deficiency of water had occurred. (Sec. 4, p. 97, Acts 1879, 1722.)

The governor shall appoint a State hydraulic engineer, who shall hold his office for the term of two years, or until his successor may be appointed and qualified. The governor may at any time, upon good cause shown, remove said State engineer. Said State engineer shall have general supervision over the water companies [commissioners] of the different water districts in the State. He shall have his office at the State capitol, in an office to be provided for him by the secretary of state, and be subject to his direction and control; who shall also furnish him with suitable furniture, postage, and such proper and necessary books and instruments as will best enable him to discharge the duties of his office. He shall be paid a salary of $2,000 per annum, payable quarterly, by the State treasurer, on warrants drawn by the State auditor. No person shall be appointed as such hydraulic engineer who is not known to have such theoretical knowledge and practical skill and experience as shall fit him for the position. (Sec. 6, pp, 119–20, Acts 1881, 1807.)

Said State engineer shall make, or cause to be made, careful measurements and calculations of the maximum and minimum flow in cubic feet per second of water in each stream from which water shall be drawn for irrigation, as may be best for affording information for irrigating purpose, commencing with those streams most used for irrigation; also, to collect facts and make report as to a system of reservoirs for the storage of water, their location, capacity and cost; and he shall keep proper and full records of his work, observations and calculations. (Sec. 7, p. 120, Acts 1881, 1808.)

Said State engineer shall, before entering on the discharge of his duties, take and subscribe an oath before some officer authorized by law to administer oaths, to faithfully perform the duties of his office, and file with the secretary of state said oath and his official bond, in the penal sum of $2,000, with sureties to be approved by the secretary of state, and conditioned for the faithful discharge of the duties of his office, and for delivering to his successor, or other officer authorized to receive the same, all moneys, implements, books and other property belonging to the State then in his hands or under his control, or with which he may be legally chargeable as such officer. (Sec. 8, pp. 120–1, Acts 1881, 1809.)

Said State engineer will have power to employ assistants at an expense not to exceed $1,500 in any one year, who shall be paid out of any moneys appropriated for that purpose, on certificate of said State engineer, showing the services rendered and the amount therefor [thereof], and on presentation of such certificate to the State auditor by the person entitled thereto, he shall issue his warrant on the State treasurer for the amount thereof, to be paid out of any appropriation as aforesaid, and not otherwise. (Sec. 9, p. 277, acts 1883, 1801.)

Said State engineer shall prepare and render to the government [governor] yearly, and oftener if required, full and true reports of his work, touching all the matters and duties devolving upon him by virtue of his office, which report shall be delivered at the time when the reports of other State officers are required by law to be made, in order that they may be laid before the general assembly at each regular session thereof. (Sec. 10, p. 121, Acts 1881, 1811.)

Said State engineer shall, on request of any party interested, on payment of his per diem, charges, and reasonable expenses, measure and ascertain the carrying capacity of any ditch, canal, or feeder, or any reservoir, hereafter constructed or enlarged, and give to the party or parties requiring his services an official certificate of the size and carrying capacity of such ditch, canal, or feeder, in cubic feet per second, as he shall find it to be at the time of measuring the same. (Sec. 11, p. 121, Acts 1881, 1812.)

For the more accurate and convenient measurement of any water appropriated pursuant to any judgment or decree rendered by any court establishing the claims of priority of any ditch, canal, or reservoir, the owners thereof shall construct and maintain, under the supervision of the State engineer, a measuring weir or other device for measuring the flow, in cubic feet per second, the water at the head of such ditch, canal, or reservoir, or as near thereto as practicable. The State engineer shall

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compute and arrange in tabular form the amount of water that will pass such weir or measuring device in cubic feet per second, at the different stages thereof, and he shall furnish a copy of a statement thereof to any water commissioners having control of such ditch, canal, or reservoir. (Sec. 12, pp. 121-2, Acts 1881, 1813.)

Whenever any three or more persons associate under the provisions of this act to form a company for the purpose of constructing a ditch for the purpose of conveying water to any mines, mills, or lands, to be used for mining, milling, or irrigating of lands, they shall, in their certificate, in addition to the matters required in section 2 of this (corporation) act, specify as follows: The stream or streams from which the water is to be taken out; the point or place on said stream, at or near which the water is to be taken out; the line of said ditch, as near as may be, and the use to which the said water is to be applied. (Sec. 274 (84), p. 171, G. L., 308.)

Any ditch company formed under the provisions of this act shall have the right of way over the line named in the certificate, and shall also have the right to run the water of the stream or streams named in the certificate through their ditch: *Provided*, That the line proposed shall not interfere with any other ditch whose rights are prior to those acquired under this act and by virtue of said certificate, except the right to cross by flume; nor shall the water of any stream be diverted from its original channel to the detriment of any person or persons who may have priority of right. (Sec. 275 (85), p. 171, G. L., 309.)

Any corporation owning any ditch or canal for conveying, or reservoirs for storing, water for irrigation purposes, and the capital stock being fully subscribed and paid up, and when such corporation shall have no income sufficient to keep its ditch, canal or reservoir in good repair, such corporation shall have power to levy an assessment upon the capital stock thereof, to be levied pro rata on all the shares of stock, payable in money or labor, or both, for the purpose of keeping the property of such corporation in good repair, and for the payment of any claim against said corporation not otherwise provided for. But no such assessment shall be made unless the question of making such assessment shall first be submitted to the stockholders of such corporation at an annual meeting, or at a special meeting called for that purpose, and a majority of the stockholders, either in person or by proxy, voting thereon shall vote in favor of making such assessments; and an action may be maintained to recover any assessment against any delinquent share-holder, as provided in section 2 of this act. (Sec. 276 (86), p. 172, G. L., 810.)

Companies organized under the laws of this State, holding ditches or canals by virtue of their organization, which derive their supply of water for their respective ditches or canals from the same head gate or gates, or the same source or sources of supply, may consolidate their interests and unite their respective companies under one name and management, by filing a certificate of that fact in the office of the secretary of this State, and a counterpart thereof in the office of the recorder of the county or counties in which such ditches or canals are situated, which certificates shall be signed by the presidents of the companies so uniting, with the common seals of the companies affixed thereto, and shall set forth the facts of such union of interests, and give the name of the new company thus formed. (Sec. 1, Acts 1876, p. 68—omitted in G. L., 313.)

All ditches used for the purpose of irrigation, and that only when the water is not sold for the purpose of deriving a revenue therefrom, be, and the same are hereby, declared free from all taxation, whether for State, county, or municipal purposes. (Sec. 1, p. 143, Acts 1872. Sec. 1384 (1), p. 517, G. L., 1761.)

Water sold by the inch by any individual or corporation shall be measured as follows, to wit: Every inch shall be considered equal to an inch square orifice under a 5-inch pressure, and a 5-inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water; said boxes or any slot or aperture through which such water shall be measured shall in all cases be 6 inches perpendicular, inside measurement, except boxes delivering less than 12 inches, which may be square, with or without slides; all slides for the same shall move horizontally and not otherwise; and said box put into the banks of ditch shall have a descending grade from the water in ditch of not less than one-eighth of an inch to the foot. (347.)

For the purpose of encouraging cultivation and the making of irrigation ditches the State board of land commissioners are hereby authorized to sell at public sale, at not less than the appraised value, not more than one-half of any tract of arid land belonging to the State, except the school land, in alternate quarter sections as nearly as may be, to any responsible person or corporation, on condition that said person or corporation dig an irrigation ditch in such location, and of sufficient capacity to furnish water for the entire tract. All contracts for the sale of State lands under the provisions of this section shall be drawn by the attorney-general, and signed by the governor and the secretary of the board, in behalf of the State, and by the other parties in interest; and in no case shall the titles to any of said lands pass from the State until such ditch is completed in a manner satisfactory to the State board, and

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the purchasers have given, in addition to such price as may be fixed by the State board, a suitable contract or agreement, secured by a sufficient bond, that they will furnish water for the remaining portion of the tract of land, as aforesaid, at not to succeed [exceed] such rates as the State board may agree. Upon the fulfillment of the above conditions patent may issue for not more than one-half of said tract, and the remaining portion of said tract may be subsequently disposed of in the same manner as other State lands. (Sec. 8, p. 226, Acts 1881, 2724.)

The State board of land commissioners may sell in parcels of not more than 5,000 acres, at public sale, at not less than its appraised value, any of the lands granted to the State for public improvements, under the act approved September 4, 1841, conditioned upon the location of colonies thereon, or the construction of extensive lines of ditches covering such lands: *Provided*, That not more than one-half of any one section of land shall be sold, in alternate half sections: *And provided further*, That every alternate one-half section unsold shall not be sold for three years thereafter. (Sec. 2196 (22), p. 728, G. L., 2744.)

When any company shall organize under the provisions of this act to form a company for the purpose of constructing a flume, their certificate, in addition to the matters required in the second section of this act (G. S., 238), shall specify as follows: The place of beginning, the terminus, and the route, as near as may be, and the purpose for which such flume is intended, and when organized, according to the provisions of this act, said company shall have the right of way over the line proposed in such certificate for such flume, provided it does not conflict with the rights of any former fluming, ditching, or other company. (Sec. 279, 80, p. 173, G. L., 316).

Act to Regulate Rates, etc., 1887.

Section 1. The county commissioners of each county shall, at their regular sessions in each year, and at such other sessions as they, in their discretion, may deem proper, in view of the irrigation and harvesting season and the convenience of all parties interested, hear and consider all applications which may be made to them by any party or parties interested either in furnishing and delivering for compensation in any manner, or in procuring for such compensation water for irrigation, mining, milling, manufacturing, or domestic purposes from any ditch, canal, conduit, or reservoir, the whole or any part of which shall lie in such county; which application shall be supported by such affidavits as the applicant or applicants may present, showing reasonable cause for such board of county commissioners to proceed to fix the rate of compensation for water to be thereafter delivered from such ditch, canal, conduit, or reservoir within such county.

Sec. 2. Every such board of commissioners shall, upon examination of such affidavit or affidavits, or from the oaths of witnesses in addition thereto, if they find that the facts sworn to show the application to be in good faith and that there are reasonable grounds to believe that unjust rates of compensation are, or are likely to be, charged or demanded for water from such ditch, canal, conduit, or reservoir, shall enter an order fixing a day not sooner than twenty days thereafter, nor later than the third day of the next regular session of their board, when they will hear all parties interested in such ditch or water works as aforesaid, or in procuring water therefrom for any of the said uses, as well as all documentary or oral evidence or depositions, taken according to law, touching the said ditch or other work as aforesaid, and the cost of furnishing water therefrom.

Sec. 3. At the time so fixed all persons interested as aforesaid on either side of the controversy, or in lands which may be irrigated from such ditch or other work aforesaid, may appear by themselves, their agents, or attorneys, and said commissioners shall then proceed to take action in the matter of fixing such rates of compensation for the delivery of water: *Provided*, The applicant or applicants—if the application be made by a party or parties as aforesaid, desirous of procuring water—shall, within ten days from the time of entering the said order fixing the hearing, cause a copy of such order, duly certified, to be delivered to the owner or owners of such ditch, canal, conduit, or reservoir, or to the president, secretary, or treasurer of the company, if it be owned by a corporation or association having such officers. If any such owner can not be found, a copy shall be left at his usual place of abode, with some person residing there, over twelve years of age, and if such officer of any corporation or association can not be found, such copy shall be left at the usual place of business of the company of which he is such officer, or at his residence, if such company have no place of business, and if such ditch or other work aforesaid shall be owned by several owners, not being an incorporated company, it shall be sufficient to serve such notice by delivering one copy each to a majority of them. If the applicant be the owner or party controlling such ditch, canal, conduit, or reservoir, such notice shall be given by causing printed copies of such order, in hand-bill form, in conspicuous type, to be posted securely in ten or more public places throughout the district watered from such ditch or other work aforesaid—if the water be used

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for irrigation—and one copy shall be posted for every mile in length of such ditch; but if such ditch or other work be for the supply of water for milling or mining, it shall be sufficient to serve such copy on the parties then taking water therefrom. The person or persons making such service or posting such printed copies shall make affidavit of the manner in which the same has been done, which affidavit shall be filed with the said board of county commissioners. Depositions mentioned in section 2 hereof, to be used before said commissioners, shall be taken before any officer in the State authorized by law to take depositions, upon reasonable notice being given to the opposite party of the time and place of taking the same.

SEC. 4. Said board of commissioners may adjourn or postpone any hearing from time to time, as may be found necessary, or for the convenience of parties, or of public business; and they shall hear and examine all legal testimony or proofs offered by any party interested as aforesaid, as well concerning the original cost and present value of works and structure of such ditch, canal, conduit, or reservoir, as the cost and expense of maintaining and operating the same, and all matters which may affect the establishing of a reasonable maximum rate of compensation for water to be furnished and delivered therefrom; and they may issue subpœnas for witnesses, which subpœnas shall be served by the sheriff of the county, who shall receive the lawful fees for all such service; and said board may also issue a subpœna for the production of all books and papers required for evidence before them. Upon hearing and considering all the evidence and facts and matters involved in the case said board of commissioners shall enter an order describing the ditch, canal, conduit, reservoir, or other work in question with sufficient certainty, and fixing a just and reasonable rate of compensation for water to be thereafter delivered from such ditch or other work as last aforesaid within the county in which such commissioners act; and such rate shall not be changed within two years from the time when they shall be so fixed, unless upon good cause shown. The district court of the proper county, or the judge thereof in vacation, may, in case of refusal to obey the subpœna of the board of county commissioners, compel obedience thereto, or punish for refusal to obey, after hearing, as in cases of attachment for contempt of such district court.

SEC. 5. Every person who shall swear or affirm falsely in any matter or testify falsely after being duly sworn or having affirmed as a witness in any proceeding provided for in this act shall be deemed guilty of perjury, and on conviction shall be punished accordingly.

SEC. 6. All acts and parts of acts inconsistent with this act are hereby repealed; but such repeal shall not work any interference with any proceeding by any board of county commissioners now pending, saving that any such proceeding may, at the request of either party, be carried on to completion under the provisions hereof.

ACT TO PREVENT EXTORTION, ETC., 1887.

SEC. 1. It shall not be lawful for any person owning or controlling, or claiming to own or control, any ditch, canal, or reservoir carrying or storing, or designed for the carrying or storing, of any water taken from any natural stream or lake within this State to be furnished or delivered for compensation for irrigation, mining, milling, or domestic purposes to persons not interested in such ownership or control to demand, bargain for, accept, or receive from any person, who may apply for water for any of the aforesaid purposes, any money or other valuable thing whatever, or any promise or agreement therefor, directly or indirectly, as royalty, bonus, or premium, prerequisite or condition precedent to the right or privilege of applying or bargaining for or procuring such water; but such water shall be furnished, carried, and delivered upon the payment or tender of the charges fixed by the county commissioners of the proper county, as is or may be provided by law. Any and all moneys, and every valuable thing or consideration of whatsoever kind which shall be so as aforesaid demanded, charged, bargained for, accepted, received, or retained contrary to the provisions of this section shall be deemed and held an additional and corrupt rate, charge, or consideration for the water intended to be furnished and delivered therefor, or because thereof, and wholly extortionate and illegal, and when paid or delivered, or surrendered may be recovered back by the party or parties paying, delivering, or surrendering the same from the party to whom or for whose use the same shall have been paid, delivered, or surrendered, together with all costs of suit, including reasonable fees of attorneys of plaintiff, by proper action in any court having jurisdiction.

SEC. 2. Every person owning or controlling, or claiming to own or control, any ditch, canal, or reservoir, as is mentioned in the first section of this act, who shall, after demand in writing made upon him for the supply or delivery of water for irrigation, mining, milling, or domestic purposes, to be delivered from the ditch, canal, or reservoir owned, possessed, or controlled by him, and after tender of the lawful rate of compensation therefor in lawful money, demand, require, bargain for, accept, receive, or retain from the party making such application any money or other thing of value, or any promise or contract or any valuable consideration whatever, as such

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royalty, bonus, premium, prerequisite, or condition precedent, as is by the provisions of the said first section of this act prohibited, shall be deemed guilty of a misdemeanor, and on conviction thereof shall be punished by fine of not less than one hundred dollars nor more than five thousand dollars, or imprisonment for a term of not less than three months nor more than one year, or both such fine and imprisonment, in the discretion of the court.

SEC. 3. Every person owning or controlling, or claiming to own or control, any ditch, canal, or reservoir such as is mentioned in the first section of this act, who shall, after demand in writing made upon him for the supply or delivery of water for irrigation, mining, milling, or domestic purposes, to be delivered from the ditch, canal, or reservoir owned, possessed, or controlled by him, and after tender of the lawful rate of compensation therefor in lawful money, refuse to furnish or carry and deliver from such ditch, canal, or reservoir, any water so applied for, which water can or may be by use of reasonable diligence in that behalf and within the carrying or storage capacity of such ditch, canal, or reservoir, be lawfully furnished and delivered, without infringement of prior rights, shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by fine of not less than one hundred dollars nor more than five thousand dollars, or imprisonment for a term of not less than three months nor more than one year, or both such fine and imprisonment, in the discretion of the court.

SEC. 4. When any corporation, in defiance or by attempted evasion of the provisions of this act, shall, after tender of the compensation hereinbefore provided for, refuse to deliver water such as is mentioned in the third section of this act to any person lawfully entitled to apply therefor, it shall be the duty of the attorney-general, upon request of the county commissioners of the proper county, or upon his otherwise receiving due notice thereof, to institute and prosecute to judgment and final determination proceedings in *quo warranto* for the forfeiture of the corporate rights, privileges, and franchises of any such corporation so offending, or by *mandamus* or other proper proceedings to compel it to its duty in that behalf.

SEC. 5. The word person as used in this act shall include corporations and associations and the plural as well as the singular number; and every officer of a corporation or member of an association or co-ownership, and every agent violating any of the provisions of this act, shall be liable to restore the unlawful consideration extorted, and be punishable under the penal provisions of this act, the same as if the thing done in disobedience to its provisions were done for his own sole benefit and advantage.

ACT TO REGULATE WATER COMMISSIONER'S BOND, ETC., 1887.

SEC. 1. That section 42 of chapter 57 of the general statutes of the State of Colorado, entitled "Irrigation," the same being general section 1752 thereof, be, and the same is hereby, amended so as to read as follows:

SEC. 42. There shall be one water commissioner for each of the above-named districts, and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioner so appointed shall, before entering upon his duties, give a good and sufficient bond for the faithful discharge of his duties, with not less than three sureties, in a sum not less than one thousand dollars nor more than five thousand dollars; the amount of said bond to be fixed by the county commissioners and approved by the governor and State engineer. The commissioner so appointed shall hold his office until his successor is appointed and qualified: *Provided, however*, That if such water district shall be embraced in more than one county, and the several counties in which such water district is situated disagree as to the amount of the bond as herein required of water commissioners, then and in that event the governor shall fix the amount thereof, with the same effect as though fixed by the county commissioners.

SEC. 2. The governor shall, by like selection and appointment, fill all vacancies which may be occasioned by death, resignation, or continued absence from the district, removal or otherwise. Said county commissioners may, from time to time, recommend persons to be appointed as above provided, and the governor may at any time remove any water commissioner, in his discretion.

ACT REGULATING DISTRIBUTION OF WATER, ETC., 1887.

SEC. 1. Every person or company owning or controlling any canal or ditch used for the purposes of irrigation shall, during the time from April 15 to November 1 in each year, keep a flow of water therein, so far as may be reasonably practicable for the purpose of irrigation, sufficient to meet the requirements of all such persons as are properly entitled to the use of water therefrom to the extent, if necessary, to which such persons may be entitled to water, and no more: *Provided, however*, That

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whenever the rivers or public streams or sources from which the water is obtained are not sufficiently free of ice, or the volume of water therein is too low and inadequate for that purpose, then such canal or ditch shall be kept with as full a flow of water therein as may be practicable, subject, however, to the rights of priorities from the streams or other sources, as provided by law, and the necessity of cleaning, repairing, and maintaining the same in good condition.

SEC. 2. The owners or persons in control of any canal or ditch used for irrigating purposes shall maintain the same in good order and repair, ready to receive water by April 15 in each year, so far as can be accomplished by the exercise of reasonable care and diligence, and shall construct the necessary outlets in the banks of the canal or ditch for a proper delivery of the water to persons having paid-up shares or who have purchased rights to the use of the water: *Provided, however,* That a multiplicity of outlets in the canal or ditch shall at all times be avoided, so far as the same shall be reasonably practicable, and the location of the same shall be under the control of and shall be at the most convenient and practicable points consistent with the protection and safety of the ditch for the distribution of water among the various claimants thereof, and such location shall be under the control of a superintendent.

SEC. 3. It shall be the duty of those owning or controlling such canals or ditches to appoint a superintendent, whose duty it shall be to measure the water from such canal or ditch through the outlets to those entitled thereto, according to his or her pro rata share.

SEC. 4. Any superintendent or any person having charge of the said ditch who shall willfully neglect or refuse to deliver water as in this act provided, or any person or persons who shall prevent or interfere with the proper delivery of water to the person or persons having the right thereto, shall be guilty of a misdemeanor, and upon conviction thereof shall be subject to a fine of not less than ten nor more than one hundred dollars for each offense, or imprisonment not exceeding one month, or by both such fine and imprisonment, and the money thus collected shall be paid into the general fund of the county in which the misdemeanor has been committed, and the owner or owners of such ditches shall be liable in damages to the person or persons deprived of the use of the water to which they were entitled, as in this act provided.

SEC. 5. Any water commissioner, or his deputy or assistant, who shall willfully neglect or refuse, after being called upon in accordance with section 1758 of the general statutes of the State, to promptly measure water from the stream or other source of supply into the irrigating canals or ditches in his district, according to their respective priorities, to the extent to which water may be actually necessary for the irrigation of lands under such canals or ditches, shall be deemed guilty of a misdemeanor, and shall be subject to the same penalty as provided in section four of this act.

SEC. 6. In all cases declared misdemeanors by this act, any justice of the peace of the county in which the offense was committed, may, upon complaint being made as is now required by law, issue a warrant directed to any proper officer of the county, for the arrest of any person so charged with any such misdemeanor, and upon the arrest of such person or persons, the justice of the peace before whom such person or persons may be brought for trial shall hear and determine the cause; and if he find the accused guilty, shall assess the fine, and if imprisonment be a portion of the sentence, then to fix the term of imprisonment, or both, as provided in section 4 of this act: *Provided,* The accused may have a trial by jury, which shall be summoned as in cases before justices of the peace for assault and battery.

AN ACT FOR APPOINTMENT OF WATER DIVISION SUPERINTENDENTS, 1887.

SEC. 1. That the governor shall appoint a superintendent of irrigation for each of the water divisions now existing within the State, or which may hereafter be created. Such superintendents of irrigation to hold office for a period of two years from the date of their respective appointments, or until their successors may be appointed and qualified. The governor may at any time in his discretion remove said superintendents of irrigation, or any of them and appoint others in their stead for the remainder of said term of two years: *Provided,* That the governor shall not appoint a superintendent of irrigation in any district [division] until the board of county commissioners of some one or more of the counties whose territory or any part of whose territory is included in such water district [division] shall have, at a meeting regularly called and held, adopted a resolution requesting such appointment to be made, and have had the same certified to the governor.

SEC. 2. Said superintendent of irrigation shall have general control over the water commissioners of the several districts within his division. He shall, under the general supervision of the State engineer, execute the laws relative to the distribution of water in accordance with the rights of priority of appropriation as established by judicial decree, and perform such other functions as may be assigned to him by the State engineer.

SEC. 3. Said superintendent of irrigation shall, in the distribution of water, be governed by the regulations of this act and acts that are now in force, but, for the better

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discharge of his duties, he shall have the authority to make such other regulations to secure the equal and fair distribution of water, in accordance with the rights of priority of appropriation as may in his judgment be needed in his division: *Provided*, Such regulations shall not be in violation of any part of this act, or other laws of the State, but shall be merely supplementary to and necessary to enforce the provisions of the general laws and amendments thereto.

SEC. 4. Any person, ditch company, or ditch owner who may deem himself injured or discriminated against by any such order or regulation of such superintendent of irrigation, shall have the right to appeal from the same to the State engineer, by filing with the State engineer a copy of the order or regulation complained of, and a statement of the manner in which the same injuriously affects the petitioner's interest. The State engineer shall, after due notice, hear whatever testimony may be brought forward by the petitioner, either orally or by way of affidavits, and through the superintendent of irrigation shall have power to suspend, amend, or confirm the order complained of.

SEC. 5. Said superintendent of irrigation shall commence the discharge of his duties in his division as soon as the first water commissioner in any district within his division shall be called out, and shall continue to discharge his duties until the last water commissioner in any district of his division ceases to be needed. Each water commissioner shall report immediately to the superintendent of irrigation of his division when he is called out and when he ceases to be needed, and shall, during the continuance of his duties, be under the control of the superintendent of irrigation of his division. The superintendent of irrigation shall receive as compensation five dollars per day for every day during which he is employed in the discharge of his duties.

SEC. 6. Within thirty days after the appointment of said superintendent of irrigation, it shall be his duty to give bond to the amount of ten thousand dollars for the faithful discharge of his duty, said bond to be approved by the board of county commissioners of the county wherein said superintendent of irrigation may reside, and to be filed in the office of the county clerk and recorder of such county.

SEC. 7. Within thirty days after his appointment said superintendent of irrigation shall send to the clerk of the district court, within his division, of such counties as have had rendered by the district court of such county, judicial decrees fixing the priorities of appropriation of water for irrigation purposes for any water district, a notification of his appointment to such office, and shall request of the said clerk a certified copy of every decree of the district court establishing priorities of appropriation of water used for irrigation purposes within that district. Thereupon it shall be the duty of the clerk within ten days after the receipt of such request from said superintendent of irrigation, to prepare a certified copy of all decrees of such district court establishing priorities of water rights made within that district, under the provisions of the general statutes of the State of Colorado, and transmit the same to the superintendent of irrigation requesting it. Said superintendent of irrigation shall then cause to be prepared a book to be entitled "The register of priorities of appropriations of water rights for water division No. ——, State of Colorado," within which he shall enter and preserve such certified copies of decree. Said superintendent of irrigation shall then, from such certified copies of decree, make out a list of all the ditches, canals, and reservoirs entitled to appropriations of water within his division, arranging and numbering the same in consecutive order according to the dates of their respective appropriations within his division, and without regard to the number such ditches, canals, and reservoirs may bear within their respective water districts. Such superintendent of irrigation shall then enter from his register a tabulated statement of all the ditches, canals, and reservoirs in his division, whose priorities have been decreed, which statement shall contain the following information concerning each ditch, canal, and reservoir, arranged in separate columns: The name of the ditch, canal, or reservoir, its number in his division, the district in which it is situated, the number of it in its proper district, and the number of cubic feet of water per second to which it is entitled, and such other and further information as he may deem useful to the proper discharge of his duty. In case any decrees of court establishing priorities of appropriation of water for irrigation purposes are made after the transmittal of the copy of previous decrees to the superintendent of irrigation, it shall be the duty of the clerk of the court wherein such decree is rendered to transmit to the superintendent of irrigation of the division within which such county is situated, within ten days after it is rendered, a copy of such decree, and the superintendent of irrigation shall enter the same in his register. Such register to be filed and kept in the office of the State engineer.

SEC. 8. Said superintendent of irrigation shall have the right to call out any water commissioner of any water district within his division at any time he may deem it necessary, and he shall have the power to perform the regular duties of water commissioner in all the districts within his division.

SEC. 9. All water commissioners shall make reports to the superintendent of irrigation of their division as often as may be deemed necessary by said superintendent.

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Said reports shall contain the following information: The amount of water necessary to supply all the ditches, canals, and reservoirs of that district; the amount of water actually coming into the district to supply such ditches, canals, and reservoirs; whether such supply is on the increase or decrease; what ditches, canals, and reservoirs are at that time without their proper supply; the probability as to what the supply will be during the period before the next report will be required; and such other and further information as the superintendent of irrigation of that division may suggest. Said superintendent of irrigation shall carefully file and preserve such reports, and shall from them ascertain what ditches, canals, and reservoirs are, and what are not, receiving their proper supply of water, and if it shall appear that in any district in that division any ditch, canal, or reservoir is receiving water whose priority post-dates that of the ditch, canal, or reservoir in another district, as ascertained from his register, he shall at once order such post-dated ditch, canal, or reservoir shut down and the water given to the elder ditch, canal, or reservoir. His orders being directed at all times to the enforcement of priority of appropriation, according to his tabulated statement of priorities, to the whole division, and without regard to the district within which the ditches, canals, and reservoirs may be located. The reports of water commissioners, by the superintendent of irrigation, shall be filed and kept in the office of the State engineer.

SEC. 10. In case any ditch, canal or reservoir, in any district within such superintendent of irrigation's division, shall fail to receive its regular supply of water, the owner of such ditch, canal or reservoir may report such fact to the water commissioner of that district, who shall immediately apportion the water in his district, and send forthwith, by telegram if necessary, a report of such fact to the superintendent of irrigation of his division; and thereupon it shall be the duty of the superintendent to compare such report with his register, and if any ditch, canal or reservoir of any other district of his division is receiving water to which any ditch, canal or reservoir of any other district is entitled, he shall at once order the shutting down of the post-dated ditches, canals or reservoirs, and the water given to the ditches, canals or reservoirs having the priority of appropriation: *Provided, however*, That nothing in this act shall be construed as interfering with the priority of water for domestic use.

SEC. 11. Such superintendent of irrigation shall, in the discharge of his duties, be clothed with the powers of justice of the peace, and any person violating his orders relative to the opening or shutting down of head-gates, or the using of water for irrigation purposes, shall be deemed guilty of contempt, and summary punishment may be inflicted, not exceeding ninety days' imprisonment, or three hundred dollars fine, or both.

SEC. 12. The expenses and salary of the superintendents of irrigation shall be paid *pro rata* by the counties interested, in the same manner as the fees of water commissioners are paid; and the fees of the clerks of the district courts, for services rendered under the provisions of this act, shall also be paid by the counties interested, upon the said clerk rendering his account, certified by the district judge, to the boards of county commissioners of the counties embraced in the water divisions, in case of which the services have been rendered.

ACT TO PROTECT WATER RIGHTS, ETC., 1887.

SEC. 1. That it shall be the duty of every person who is entitled to take water for irrigation purposes from any ditch, canal, or reservoir to see that he receives no more water from such ditch, canal, or reservoir through his head-gate or by any ways or means whatsoever than he is entitled to, and that he shall at all times take every precaution to prevent more water than he is entitled to coming from such ditch, canal, or reservoir upon his land.

SEC. 2. That it shall be the duty of every such person taking water from any ditch, canal, or reservoir to be used for irrigation purposes, on finding that he is receiving more water from such ditch, canal, or reservoir either through his head-gate or by means of leaks or by any means whatsoever, immediately to take steps to prevent his further receiving more water from such ditch, canal, or reservoir than he is entitled to, and if knowingly he permits such extra water to come upon his land from such ditch, canal, or reservoir and does not immediately notify the owner or owners of such ditch, or take steps to prevent its further flowing upon his land, he shall be liable in damages to any person, company, or corporation who may be injured by such extra appropriation of water for the actual damage sustained by the party aggrieved, which damages shall be adjudged to be paid together with the costs of suit and a reasonable attorney's fee to be fixed by the court and taxed with the costs.

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ACT TO SECURE RIGHT OF WAY, ETC., 1887.

Be it enacted by the general assembly of the State of Colorado:

SEC. 1. That section two (2) of said act (approved February 11, 1881, being general section No. 1720 of the general statutes of the State of Colorado, which is section 10 of chapter 57 of said general statutes, entitled "Irrigation," be, and the same is hereby, amended so as to read as follows:

SEC. 2. Every person, association, or corporation hereafter constructing or enlarging any ditch, canal, or feeder for any ditch or reservoir for irrigation, and taking water directly from any natural stream, and of a carrying capacity of more than one cubic foot of water per second of time, as so constructed or enlarged, shall, within ninety (90) days after the commencement of such construction or enlargement, file in the office of the county clerk and recorder of the county in which the head-gate of such ditch or feeder may be situated, and also in the office of the State hydraulic engineer, a map showing the point of location of such head-gate, the route of such ditch or canal, or the high-water line of such reservoir or reservoirs, and the route of the feeder to and ditches or canals from such reservoir or reservoirs; the legal subdivisions of the lands upon which such structures are built or to be built, if on surveyed lands; the names of the owners of such lands as far as the same are of record in the office of the county clerk of the county in which they are situated; such courses, distances, and corners, by reference to legal subdivisions, if on surveyed lands, or to natural objects if on unsurveyed lands, as will clearly designate the location of such structures. Upon or attached to such map shall be a statement showing:

First. The point of location of the head-gate above mentioned.

Second. The depth, width, and grade of such ditch, canal, or feeder.

Third. The carrying capacity of such ditch, canal, or feeder, in cubic feet per second of time, and the capacity of such reservoir or reservoirs in cubic feet when filled to the high-water mark.

Fourth. The time of commencement of work on such structures, which time may be dated from the commencement of the surveys therefor. In case of an enlargement, such statement shall also show the matters required in items second, third, and fourth above, as to the enlargement, and state the increased capacity arising from such enlargement. If such statement be filed within the time above limited priority of right of way and water accordingly shall date from the day named as the day of commencing work; otherwise only from the date of the filing of the same: *Provided*, That nothing herein contained shall be taken to dispense with the necessity of due diligence in the prosecution of such structures on the part of the projectors of the same. Such statement shall be signed by the person, association, or corporation on whose behalf it is made, and the truth of the matters shown in such map and statement shall be sworn to by some person in whose personal knowledge the truth of the same shall lie.

DAKOTA IRRIGATION LAWS.

[The Territorial laws have been adopted in both North and South Dakota.]

WATER RIGHTS.

SEC. 2029. Any person or persons, corporation or company, who may have or hold a title or possessory right or title to any mineral or agricultural lands within the limits of this Territory shall be entitled to the usual enjoyment of the waters of the streams or creeks in said Territory for mining, milling, agricultural, or domestic purposes: *Provided*, That the right to such use shall not interfere with any prior right or claim to such waters when the law has been complied with in doing the necessary work.

SEC. 2030. When any persons, corporation, or company owning or holding land, as provided in section 2029, shall have no available water facilities upon the same, or whenever such lands are too far removed from any stream or creek to so use the waters thereof as aforesaid, such person or persons, corporation or company shall have the right of way through and over any tract or piece of land for the purpose of conducting and conveying said water by means of ditches, dikes, flumes, or canals, for the purpose aforesaid.

SEC. 2031. Such right to dig and construct such ditches, dikes, flumes, and canals over and across the lands of another shall only extend to so much digging, cutting, or excavation as may be necessary for the purposes required.

SEC. 2032. In all controversies respecting rights to water under the provisions of this act the same shall be determined by the date of appropriation as respectively made by the parties, whether for mining, milling, agricultural, or domestic purposes.

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SEC. 2033. The waters of the streams or creeks of the Territory may be made available to the full extent of the capacity thereof for mining, milling, agricultural, or domestic purposes, without regard to deterioration in quality or diminution in quantity, so that the same do not materially affect or impair the rights of the prior appropriator.

SEC. 2034. Any person or persons, corporation or company, damaging or injuring the lands or possessions of another by reason of cutting or digging ditches or canals or erecting flumes as provided by section 2030, the party so committing such injury or damage shall be liable to the party so injured for the actual damage occasioned thereby.

SEC. 2035. This act shall not be so construed as to impair or in any way or manner interfere with the rights of parties to the use of the waters of such streams or creeks acquired before the passage of this act: *Provided*, That all water rights or ditches that have not been used or worked upon for one year next prior to the passage of this act shall be deemed abandoned and forfeited and subject to appropriation anew. Any person or persons, corporation or company who may dig any ditch or canal, dike, or flume over or across any public road, trail, or highway, or who use the waters of such ditch, dike, flume, or canal shall be required to bridge the same and keep the same in good repair at such crossing or other places where the water from any such ditch, dikes, flumes, or canals may flow over or in anywise injure any road, trail, or highway, either by bridges or otherwise.

SEC. 2036. Any person or persons, corporation or company offending against section 2035, on conviction thereof shall forfeit and pay for every such offense a penalty of not less than twenty-five dollars nor more than one hundred dollars, to be recovered with costs of suit in civil action in the name of the Territory of Dakota, before any court having jurisdiction. One-half of the fine so collected shall be paid into the county treasury of the county in which the offense was committed, and the other half shall be paid to the person or persons informing the nearest magistrate that such offense has been committed. All such fines and costs shall be collected without stay of execution, and such defendant or defendants may by order of the court be confined in the county jail until such fine and costs have been paid.

SEC. 2037. Any person or persons, corporation or company appropriating the waters of any streams or creeks in this Territory shall turn the water from the channel of such creek or stream, and construct at least twenty feet of ditch or flume, within thirty days from the date of appropriation, and turn the water therein; and construct at least twenty rods of said ditch or flume, if needed, within six months from the date of such appropriation, and turn the water therein; and within twenty days from the date of location, the locator or locators of such water right shall file a location certificate thereof with the register of deeds in the proper county within which such water right is situated; a copy of such certificate shall be posted at or near the head of such ditch, flume, or canal, and shall contain the name or names of the locators, the date of location, number of inches of water claimed or appropriated, and the purpose of the appropriation; and in no case shall the number of inches of water claimed exceed the conveying capacity of the first twenty feet of the flume or ditch, nor shall said ditch or flume be enlarged to the prejudice or injury of a subsequent appropriator before such enlargement.

SEC. 2038. On failure to commence the construction of such ditch or flume for sixty days after location, and prosecute such ditch, canal, or flume to final completion without unnecessary delay, such appropriation shall be deemed abandoned.

SERVITUDES.

SEC. 2760. The following land burdens or servitudes upon land may be attached to other land as incidents or appurtenances, and are then called easements:

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4. The right of way.
5. The right of taking water, etc.

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9. The right of receiving water from or discharging the same upon land.
10. The right of flooding land.
11. The right of having water flow without diminution or disturbance of any kind.

RIGHTS AND OBLIGATION OF OWNERS.

SEC. 2771. The owner of land owns water standing thereon or flowing over or under its surface, but not forming a definite stream. Water running in a definite stream, formed by nature over or under the surface, may be used by him as long as it remains there; but he may not prevent the natural flow of the stream, or of the natural spring from which it commences its course, nor pursue nor pollute the same.

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ARTESIAN WELLS.

SECTION 1. [*Commissioner created.*] That for the purpose of carrying into effect the provisions of this act, the judge of probate of each county shall be *ex officio* county artesian well commissioner, which office is hereby created.

SEC. 2. [*Application by ten resident freeholders.*] Before the artesian well commissioner shall take any action toward creating or establishing any artesian well, there shall be filed with him an application, signed by not less than ten resident freeholders of any township or townships in which such artesian well and the lands to be benefited thereby and to be assessed therefor may be situated, giving a description of the place where said well is proposed to be located, and also a definite description of the beginning, the route, and the terminus of the water-way through which it is proposed that the water from such well shall flow when the same is completed and in operation, and offering the right of way for said well and such water-way through their said land, and who shall be subject to direct assessment therefor.

SEC. 3. [*Appointment of viewers—duties.*] At the expiration of twenty days after the filing of such application the said commissioners shall appoint three disinterested persons as viewers who shall without unnecessary delay proceed to personally examine the place where said well is to be located and the course, route, and terminus of said proposed water-way, and shall ascertain whether said location of such well and establishment of said water-way is practicable and necessary and beneficial to the public welfare of the district in which the same is proposed to be located, and shall report the result of such investigations in writing to said well commissioner, having first been duly sworn to faithfully and impartially discharge their duties as such viewers. If any person upon whose land the proposed well is located, or through whose land any water-way therefrom may pass, shall have filed any protest against the location of said proposed well and water-way, prior to the appointment of said viewers, they shall assess the damages, if any, which such person may sustain from the location of such well or said water-ways through his land, and shall report said damages with the report of their proceedings made as heretofore provided.

SEC. 4. [*Report when damages assessed.*] If a majority of the viewers assess and report damages in favor of any person protesting against the location of such well or its water-ways, their report shall be presented to the board of county commissioners of said county, and if said board shall consider the proposed well of sufficient importance to the public they shall order the costs and damages to be paid out of the county treasury; but if a majority report against the claims for damages of such person he shall be liable for the costs of such appraisement.

SEC. 5. [*Power of county commissioners.*] If it shall be made to appear to the board of county commissioners that the damages assessed are unreasonable they may set aside such assessment, and in such case the artesian-well commissioner may order another appraisement by different persons, under the same regulations as provided in the first appraisement.

SEC. 6. [*Appeal to district court.*] Any person aggrieved by any decision of any board of commissioners had under this chapter may appeal therefrom to the district court, the same as provided relating to highways, bridges, and ferries. (Section 29, chapter 29, Political Code, 1217 General Laws.)

SEC. 7. [*Fee of viewers.*] The viewers appointed under the provisions of section 3 of this act shall receive the sum of two dollars per day for their services as desribed in said section, to be paid by the persons who signed the application for said well, who shall be severally liable to pay the same.

SEC. 8. [*Survey after favorable report—plat filed.*] If the viewers make and file a written report with said commissioners recommending said location and route as practicable, necessary, and beneficial the commissioners shall cause a survey and measurement of the location of said well and the line of the proposed water-way to be made by the county surveyor, and a plat thereof shall be filed in the office of the register of deeds of said county, and be subject to public inspection, and shall show the location of the well and the lines and route of the water-way therefrom.

SEC. 9. [*Order of location by commissioner—damages.*] Upon the filing of the plat and the minutes of said survey as provided in said section 5, the said commissioner shall make an order in writing in which he shall declare said well and said water-ways therefrom to be located in accordance with said plat and survey: *Provided*, That in cases where damages have been appraised and assessed, the same shall first be paid to the person entitled thereto, or paid into the county treasury for their use, before such lands shall be actually taken.

SEC. 10. [*Railway's contribution to water-way—penalty—collection.*] Whenever it is necessary to construct a water-way from any artesian well across the right of way or road-bed of any railroad company it shall be the duty of the railroad, when notified by the commissioners to do so, to make and maintain the necessary opening through said road-bed, and to build and maintain a suitable culvert. Notice in writing to make such opening and to construct such culvert may be served on such company as

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provided in the service of summons, at least thirty days before such railroad company shall become liable.

In case such railroad company shall refuse or neglect to comply with the provisions of this section, it shall be liable to a penalty of ten dollars for each day's refusal or neglect to make such opening and construct such culvert. The district attorney of the county in which such railroad company shall have refused or neglected to comply with the provisions of this section, shall upon complaint being made by the artesian-well commissioner bring suit to collect such penalty or fines, and it shall be his duty to prosecute the same to a final determinatin in any court having competent jurisdiction.

SEC. 11. [*Duty of road overseers, etc.*] All that part of such artesian well or artesian-well water-course, which is laid and constructed within the limits of or across any public highway shall be under the jurisdiction of the overseer of public highways or road supervisors, and it shall be his duty to keep the same open and free from all obstructions, and when any highway is subsequently constructed along or across such artesian-well water-way then so much thereof as shall come within the limits of such highway shall also be kept open and free from obstructions as above provided.

SEC. 12. [*Name of well.*] In his order locating any well under the provisions of this act the artesian-well commissioner shall give the same a name by which it shall be known and recorded.

SEC. 13. [*Advertise for bids for construction—contract—security.*] After making said order locating said well and the water-ways thereof, the artesian-well commissioner shall proceed to advertise for bids for contracts for sinking or making such well, and constructing said water-ways. He shall give not less than sixty days' notice of the time and place where such bids may be offered and opened, by causing a notice thereof to be published, not less than eight weekly insertions, in the official paper of said county, such bids shall be filed with the county clerk of said county by the parties making the same, and shall be taken subject to the approval of the board of county commissioners of said county. No contract made by the artesian well commissioner shall be valid unless approved by the board of county commissioners of such county, and their approval indorsed thereon by the chairman of said board.

The artesian well commissioner shall contract with the lowest responsible bidder giving adequate security for the performance of the work.

Such security shall cover the completion of the job in the manner and within the time fixed in the contract, and the amount thereof shall be fixed by said artesian-well commissioner. Said commissioner shall reserve the right to reject any and all bids, and may adjourn the time for receiving such bids from time to time by publishing a notice of such adjournment, but not in all more than sixty days from and after the time named in the first advertisement for receiving such bids. The contract for sinking the well may be separate from the contract for constructing the water-ways, and may be let to different persons. Whenever any such artesian well shall have been fully completed and final report thereof made by the well commissioner to the board of county commissioners, the said board shall turn over the control and management of said well and appurtenances to the board of supervisors of the township wherein said well is situated.

SEC. 14. [*Board of assessment—meetings.*]—Immediately after making his order locating said well, the artesian-well commissioner shall notify the chairman of the board of county commissioners and the county treasurer of said county, who shall, together with said well commissioner, constitute a board of assessment herein. The county clerk of said county shall be the clerk of said board of assessment. The members of said board shall meet within twenty days after receiving said notice, and may adjourn from day to day until their duties are performed as hereinafter set forth.

SEC. 15. [*Mode of assessment and apportionment—tax collection.*]—The said board of assessment shall make an estimate of the costs of constructing said artesian well and the said water-ways, for the purpose of raising the funds necessary for the construction of said well. They shall have power to apportion the costs thereof as follows:

(1) They shall create a county fund to be known as the artesian well fund, and may levy an assessment upon all taxable property in said county, not exceeding two mills on the dollar, and the basis of value upon which the annual levy of the current or preceding year was made: *Provided*, That not more than one-tenth of the cost of any artesian well, or water-ways therefrom, shall be paid out of said fund, and the amount so paid shall be applied to the payment of the expenses and per diem of the well commissioners, the viewers, surveyors, members of the board of assessment, damages for right of way, and other like incidental expenses.

(2) They shall determine what portion of the costs of said well and its water-ways shall be paid by each of the townships in which said well or said water-courses therefrom are situated: *Provided*, That in no case shall the amount apportioned to any one township exceed one-fourth of the estimated cost of such well and water-ways,

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and the county clerk shall present a statement of such amount to the respective clerks of such townships if organized; and said board of assessment shall establish and determine the rate of assessment necessary in such townships to raise the amount so apportioned to such townships. It shall then be the duty of the officers of such townships, who have similar duties to perform in other matters of township revenue, to levy, and they are hereby empowered to levy, an assessment upon the taxable property of said township, not exceeding the rate fixed by the board of assessment for such township, which shall be placed upon the tax list under the head of "General township tax for artesian well purposes," and collected as other township taxes are collected, and shall be held by the county treasurer when collected as a distinct fund to be disbursed, as hereinafter provided, to pay for constructing such well.

(3) In addition to the foregoing general township and county assessments, the said board of assessment shall also make a special assessment against each piece and parcel of land directly benefited by said well and said water-courses, carefully adjusting the per cent. and amount of such assessments with reference to the relative distance of such lands from the well itself and the water-courses, and the amounts so apportioned shall be levied as a special tax upon said land, and shall be placed upon the tax list by the county clerk or auditor under the head of "Direct tax for artesian well," and shall be paid into the county treasury as other taxes, and kept by said treasurer in a special fund to pay for the cost of constructing said well and said waterways; said assessment shall be for a sufficient amount with the general county and township tax aforesaid to pay for said well and water-ways.

SEC. 16. [*Annual installments.*]—Said board of assessment may provide that the entire amount necessary to pay for the construction of said well and water-courses be levied and collected as above in one year, or they may divide the same into two, three, four, or five equal installments, one of which shall be collected the first year, and one installment each year following, provided that the portion designated as county and township tax shall all be collected the first year.

SEC. 17. [*Review of assessment—appeal.*]—The owner of any lands directly assessed for the construction of any artesian well under the provisions of this act, who may feel aggrieved by such assessment, may at any time before such tax becomes delinquent appear before the board of county commissioners of the county in which such assessment was made, and ask to have said assessment as to his property reviewed, and said board shall have the right to raise or lower his assessment, so as to make it just and reasonable, and an appeal may be taken from the action of said board as in other cases.

SEC. 18. [*Disqualifications by interest—vacancy—how filled.*] No member of any county board, and no county officer, whose lands have been directly assessed under this act, shall act on the board of assessment. In case any member of such board is so disqualified, his place shall be filled by calling in the sheriff of said county, or, if said sheriff is so disqualified, the county coroner may act on said board.

SEC. 19. [*Benefits—principle of assessment.*] All assessments of benefits under the provisions of this act shall be upon the principle of benefits derived. All descriptions of land under the provisions of this act shall be made by giving the legal subdivision thereof whenever practicable, and when the tract of land which is to be benefited or affected by such well is less than such legal subdivision it may be described by designation of the lot or other boundaries, or in some way by which it may be known.

SEC. 20. [*Additional assessment.*] Whenever the amount assessed for the construction of any well shall not be sufficient to complete the same, and to pay all the costs and incidental expenses, a further assessment shall be made to meet the deficit or additional expense. Such further assessment shall be apportioned, assessed, levied, and collected as provided in the first instance, and on the same percentage, and shall be collected in one year.

SEC. 21. [*Enrollment of tax by clerk.*] It shall be the duty of the county clerk to spread on his roll the total amount of all the well taxes determined upon by the board of assessment, to be assessed upon any township at large, as a part of the township tax for the year, and he shall also spread upon said roll separately, and immediately following the other descriptions, all tracts or parcels of land specially assessed for benefits, and shall place opposite each description the amount of taxes apportioned thereon for such benefits. All wells shall be entered separately, naming each well.

SEC. 22. [*Collection—mode of.*] All taxes assessed under the provisions of this act shall be collected in the same manner as Territorial and other general taxes are collected, and collecting officers are hereby vested with the same power and authority in the collection of such taxes as are or may be conferred by law for collecting general taxes. All taxes levied under the provisions of this act, with all lawful costs, interests, and charges, shall be and remain a perpetual lien upon the lands upon which they are assessed, and a personal claim against the owner or owners of such lands until they are paid.

SEC. 23. [*Sale for delinquency.*] If the taxes levied for the construction of any well are not paid to the county treasurer as provided herein, he shall proceed to sell the

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said lands for such taxes, at the same time and in the same manner in every respect, as in the case of any other tax and with like effect.

SEC. 24. [*Compensation of officers.*] The artesian-well commissioner and the members of the board of assessment herein provided for shall receive for their services a sum not to exceed three dollars per day for each day actually and necessarily spent by them in the discharge of their respective duties as hereinbefore described. All expenses, except on contract for constructing said well or such water-courses, shall be paid out of the general fund of the county on the order of the board of county commissioners, as other claims against the county are paid; said fund to be reimbursed out of the first money collected under the provisions of subdivision 1 of section 15 of this act.

SEC. 25. [*Blanks drawn by attorney-general.*] It shall be the duty of the attorney-general to draught a complete set of all the blank forms that may be required under this act, and county clerks are authorized, and it shall be their duty, to procure at the expense of their respective counties the necessary books and blanks to carry out the provisions of this act.

SEC. 26. [*Mode of payment to contractor.*] No payment shall be made to any person contracting to construct or sink an artesian well or any water-course therefrom under the provisions of this act except as follows: One-third of the amount to be paid for the entire performance of the contract may be paid when one-third of said work is done; one-third of said amount may be paid when two-thirds of said work is completed; but the balance of said amount shall not be paid until said contract has been fully completed and the work accepted and approved by the artesian-well commissioner. The said payments shall be made in the following manner: The contractor shall make a statement of the amount claimed by him to be due under his contract, and if the same is correct it shall be approved by the artesian-well commissioner, whose duty it shall be to carefully examine the work done under said contract; said claim so approved shall be presented to the board of county commissioners, and if correct, they shall issue county orders or warrants upon the well funds of each particular well, naming it: *Provided*, That if the assessment of taxes for such well has been divided into installments, as provided in this act, said board shall not issue orders payable in any one year for a larger amount than the said installment for that year, but shall draw as near as may be to the exact amount of such installment. When such orders or warrants are presented to the county treasurer for payment, if he has not yet received sufficient funds to pay the same, then such orders may be indorsed and registered as other county warrants under the general law, and shall bear the same rate of interest as other warrants.

SEC. 27. [*Description of assessed lands filed with register—lien.*] The clerk of the board of assessment provided for in this act shall make a statement of the direct assessment for benefits made against the several pieces and parcels of lands, giving a description of such lands, the amount of the direct assessment against each piece or parcel, the name of the well for which the assessment was made, and shall file the same with the register of deeds of said county, and the same shall thereafter be a lien upon said lands to secure the payment of any orders or warrants issued as herein provided; which lien may be foreclosed by the holder of such warrants or orders, and shall be prior to all other liens except for taxes.

SEC. 28. [*Water-course unobstructed, duty of overseer of highways.*] It is hereby made the duty of every person through whose land any water-course constructed under this act may pass to keep the same open and unobstructed. On failure so to do, any person aggrieved may complain to the overseer of highways in the district where such water-course is situated, and such overseer shall have the authority, and it is hereby made his duty, to call out the persons residing in said district who are liable for road tax, and open said water-way, and the expense thereof shall be entered by the county clerk as a tax against said land.

SEC. 29. [*Repeal.*] All laws heretofore enacted on the subject of artesian wells are hereby repealed: *Provided*, That all proceedings heretofore had and all contracts made under the provisions of existing laws on the subject of artesian wells are hereby declared to be valid and may be continued and completed under the provisions of this act.

SEC. 30. [*Effect when.*] This act shall take effect on the 1st day of July, 1889.

Approved March 8, 1889.

IDAHO IRRIGATION LAWS.

The general laws of Idaho, 1881, in an act regulating rights to the use of water for mining, agricultural, manufacturing, and other purposes, contain the following provisions, and which have been adopted as part of the State laws:

SECTION 1. The right to the use of water flowing in a river, creek, cañon, ravine, or other stream may be acquired by appropriation, and as between appropriations priority in time shall secure the priority of right.

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SEC. 2. The appropriation must be in good faith, for some useful and beneficial purpose, and when once perfected, may be converted or changed to any other beneficial use than that originally designated or for which it may have been employed.

SEC. 3. The appropriator, or his or their successors in interest, may change the place of diversion, if the rights acquired by others are not interfered with, and no injury to others results therefrom, and may also extend any ditch, canal, flume, pipe, or other conduit to points or places beyond such as may have accrued prior to such extension.

SEC. 4. A person, company, or corporation desiring to appropriate water must post a notice in writing in a conspicuous place, at the point of intended diversion, stating—

First, the quantity of water intended to be claimed and diverted, giving the number of inches, measured under a 4-inch pressure, and accurately describing the point of its diversion.

Second, the purpose for which the same is claimed or intended to be used, and the point or place of such intended use.

Third, the means which are designed to be employed for diverting and conducting the waters, and the size or dimensions of the ditch, canal, pipe, flume, or other conduit. A copy of the notice, within the time allowed for a mining claim, must be furnished to the county officer for record.

SEC. 5. Within sixty days after the notice is posted the claimant or his or their successors in interest must commence the making, digging, or constructing of the ditch, canal, flume, or other conduit, the work for the complete diversion and conducting of the water shall be prosecuted diligently and without unnecessary interruption: *Provided*, That when the work can not be carried on by reason of unavoidable natural causes, such as the state of the weather or action of the elements, this section shall not be applicable.

SEC. 6. By "complete diversion" is meant the conducting of the water claimed to the place of intended use, or to such other place as may have been adopted, and an actual beneficial use made.

SEC. 7. By compliance with the above conditions and requirements the appropriation is perfected, and the right to the use of the waters claimed, which the ditch, canal, flume, or other conduit is capable of conducting, is declared to relate back to the time of the posting of notice of claim: *Provided*, That nothing contained in this section shall be so construed as to render any person or party liable to damages or to make compensation to any appropriator for any waters used prior to the time of a "complete diversion."

SEC. 8. All ditches, canals, and other works heretofore made, constructed, or provided, and by the means of which the waters of any stream have been diverted and applied to any beneficial use, shall be taken to have secured the right to the waters claimed to the extent of the quantity which the works are capable of conducting, and not exceeding the quantity claimed, without regard to or in compliance with the requirements of this act.

SEC. 9. In case where any person, company, or corporation have heretofore made claim to divert the waters of any stream and the same has not been forfeited or abandoned, and have not cut, excavated, made, or constructed the necessary ditch, canal, flume, or other conduit to carry such waters and apply the same to a beneficial use, such claimant must, within four months from and after the date of the approval of this act, commence work in pursuance with the requirements, and carry the same to completion, or at the expiration of the time or upon failure to prosecute the work in the manner required, the claim shall cease to be of any validity as to the foundation of a right to the waters of any stream.

SEC. 10. All persons, companies, and corporations owning or claiming any lands situated on the banks or in the vicinity of any stream shall be entitled to the use of the waters for the purpose of irrigating the land so held or claimed.

SEC. 11. Whenever any such owner or claimant to land has not sufficient length of frontage on a stream to afford the requisite fall for a ditch, canal, or other conduit in his own premises, or where the land proposed to be irrigated is back from the banks of the stream and convenient facilities for watering the land can not be had, the owner or claimant shall be entitled to the right of way through the lands of others for the purposes of irrigation: *Provided*, That in making, constructing, keeping up, and maintenance of the ditch, canal, or conduit through the lands of others, the person, company, or corporation and those succeeding to the interest of the same shall keep the ditch, canal, or other conduit in good repair, and shall also be liable to the owners or claimants of the lands crossed for all damages which may be occasioned by an overflow or result from any neglect or accident (unless the same be unavoidable).

SEC. 12. In case of the refusal of the owners or claimants of any lands through which such ditch, canal, or other works are proposed to be made or constructed, to allow a passage, the persons, company, or corporation desiring the right of way may present a petition to the county commissioners describing the lands to be crossed, the size of the ditch, canal, or works, the quantity of land required, giving the names of

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the owners or parties interested, and asking for appointment of three appraisers to ascertain the compensation to be made. When the petition is filed the county commissioners shall give notice, either by newspaper publication or notices in three public places, one the county seat, that the appraisers will be appointed, unless good cause be shown by the parties adversely interested why the petition should be denied. The notice must be published or posted not less than thirty days prior to the hearing, and the expense defrayed by the petitioners.

SEC. 13. The appraisers shall impartially hear the proofs and allegations offered by the respective parties, and, after viewing the lands and premises, shall ascertain and certify the compensation proper to be paid for the right of way to the parties owning or interested in the lands to be crossed and the damages, if any, after making allowance for real or direct benefits which the owner or party interested may desire from the making of a ditch, canal, or other works. They, or a majority of them, shall subscribe the certificate, and it shall be recorded in the county recorder's office, and upon the payment or tender of the compensation and damages, if any, or the deposit of such amount in the county treasury to the credit of the party or parties interested, the persons, companies, or corporations shall have the right of way for the proposed ditch, canal, or other works.

SEC. 14. All persons, companies, or corporations owning or having the possessory title or right to lands adjacent to any stream, shall have the right to place in the channel of or upon the banks or margin of the same, rams or other machines for the purpose of raising the water to a level above the banks of such heights as may be requisite for its flow to and upon the lands, and the right of way over and across the lands of others for conducting the water may be acquired in the manner heretofore mentioned.

SEC. 15. Where the owners of any spring or the appropriators of any stream may desire to conduct the waters to any lands for irrigation, or to any city or town for the use of the inhabitants, or to any factory, or to any distant place, with the intent to apply the same to a beneficial use, and where to accomplish the object it may be necessary to cross with ditches, flumes, or other conduit the lands owned and occupied by others than the owners or appropriators of the spring or stream, the right of way over and across the lands of others may be acquired in the manner prescribed in the preceding section.

SEC. 16. The owners or constructors of ditches, canals, works, or others aqueducts, and their successors in interest, using and employing the same to convey the waters of any stream or spring, whether the ditches, canals, works, or aqueducts be upon the lands owned or claimed by them or upon other lands, shall keep and maintain the same, and the embankments, flumes, or other conduit by which the waters are or may be conducted, in good repair and condition, so as not to damage or in any way injure the property or premises of others.

SEC. 17. Nothing in this act shall be so construed as to interfere with or impair the rights to water appropriated and acquired prior to the passage of this act, but this reservation in behalf of existing rights shall not exempt such appropriatiors from liability as heretofore provided.

SEC. 18. In case the volume of water in any stream shall not be sufficient to supply continually the wants for irrigating purposes of the owners or proprietors of land in any district or neighborhood in which customs exist for distributing the waters amongst such owners or proprietors, the water diverted shall, in such case, be held to be a common right in those accustomed to a participation in the use and enjoyment of the distribution, and such custom shall be upheld in all courts as conferring the common right in the same: *Provided*, That this section shall not be construed to affect any prior vested right.

SEC. 19. In case any person, company, or corporation shall have constructed a ditch for the purpose of directing the water of any river, creek, cañon, ravine, or spring, for the purpose of selling the water for irrigating purposes, the owners or cultivators of land along the line of, and covered by, the ditch or canal shall be entitled to, and have the right to, the use of water for the purpose of irrigating in the following order: First, all persons through whose land the ditch or canal runs shall be entitled to the use of the water in the order of their location; second, after those through whose land the ditch or canal runs, those upon either side of the line of the ditch or canal shall be entitled to the use of the water; those equally distant from the line shall be entitled to priority in the order of their location along the line: *Provided always*, That the owners or cultivators of such lands shall pay the usual and customary rates for the use of the water, and whenever any ditch or canal has been constructed for the purpose of conveying water and selling the same for irrigating purposes it shall be unlawful for the owner or owners to change the line so as to prevent or interfere with the use of water by any one who, prior to the proposed change, had used water for irrigating purposes. And it is the duty of the owner or owners to keep the same in good repair, and to cause the water to flow through to the extent of its capacity, provided so much may be needed during the entire time that water may be

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necessary for irrigating purposes: *And provided further*, That the river, creek, cañon, ravine, or spring from which the water is taken furnishes an amount of water sufficient for such purpose, subject to the appropriation of the owner or owners of the ditch or canal. For a failure to cause the water to flow, the owner or owners or lessees of any such ditch shall be personally liable to any one for any danger resulting from the failure; and in addition to personal liability the damages shall be a lien upon the ditch or canal, which shall continue in force until the damages are paid. No person entitled to the use of water from any such ditch or canal shall, under any circumstances, use more water than good husbandry shall require for the crop or crops that he shall cultivate; and any person using an excess of water shall be liable to the owner or owners for the value of the excess, and, in addition, shall be liable to all damages sustained by any other person who would have been entitled to the use of the excess of water.

The General Laws of 1881, in an act regulating the distribution of water for purposes of irrigation, in substance is as follows:

SECTION 1. The inhabitants of any vicinity or neighborhood who use the waters of any ditch, stream, or spring for the purpose of irrigation, or have or claim a common right to the same for such purposes, shall constitute a water district, and a majority of the inhabitants having the common right may annually, on the fourth Monday of March, elect a water-master, whose duties shall be to superintend the distribution of the waters among those having the common right. The water-master shall file a bond, faithfully to perform his duties, in the sum of $500, with two sufficient sureties in the county recorder's office of the county wherein the district is situated, and he shall employ one or more deputies, as authorized by the inhabitants of his district, and they shall receive such compensation as the inhabitants agree upon.

SEC. 2. The owner or owners of any ditch for the distribution and sale of water for the purposes of irrigation shall employ a water-master for the distribution of the water of the ditch to the persons purchasing the same for such purposes, and no account or demand for the use of the water during any time the water-master is not so employed shall be valid or collectible.

SEC. 3. The water-master and his deputies shall regulate the distribution of water among the several ditches of his district and among the several inhabitants entitled and accustomed to the use according to their respective rights and necessities, and when the quantity of water is not sufficient to afford a supply to those entitled to it, the water-master and his deputies shall regulate the quantity to be used by each person and the time at and during which each person may use the same: *Provided*, That nothing in this act shall be so construed as to interfere with the individual right of companies or corporations, or in any manner interfere with the rights of individuals, companies, or corporations, to the use and control of water which is or may be their private property.

SEC. 4. Where a ditch is common property, or there is a common right to the use of the water of a ditch without payment, and any labor or materials are necessary for the repair or cleaning of the ditch, or any gate or flume on or belonging to it, the water-master may make a fair pro rata assessment of labor or materials against the inhabitants of the district claiming the use of such water according to the benefits received by each, and if any person so assessed shall neglect or refuse, for the period of ten days after notice, to furnish his just proportion of labor or materials, he shall forfeit all rights to the use of the water from the ditch for the year in which he shall make such defaults.

SEC. 5. The water-master shall see that there are provided the necessary and proper head-gates and dams, and that the water is turned and runs into the ditches of his district at the proper season of the year; and he may require all persons receiving water to construct proper gates at the points at which they take water from any ditch, dam, or reservoir; and he shall have such control of the location of ditches and gates as may be necessary to secure the most equitable distribution of the water among those entitled to its use.

SEC. 6. Any person who shall, without the consent of the water-master of the district, divert any water from the ditch or channel where it was placed or caused or left to run by the water-master and his deputies, or who shall shut or open any ditch, gate, or dam with intent so to divert any water, and thereby deprive any person of the use of the same during any part of the time he is entitled to it, or who shall cut any ditch or the banks thereof, or break or destroy any gate or flume, shall be fined not less than five nor more than twenty dollars, and shall be liable to any person injured in three times the actual damage sustained.

IN KANSAS.

Irrigation companies have the right of way through any lands or lots, and, with the consent of the municipal authorities, through any street, alley, or public ground of any city of the second or third class, and may use as much water as is necessary for the purpose for which they were organized, but no injury shall result to milling or

other improvements already constructed. Any such company may sell or lease any portion of its water, transmit power by shafting, etc., borrow money necessary for comp eting and operating its works, issue bonds therefor, and mortgage the company property as security, enter upon any property for the purpose of making surveys, hold voluntary grants made in aid of the construction and maintenance of the works, construct a canal not more than 50 feet wide, and furnish water at such rates as its by-laws may prescribe.

Any person or company furnishing water to irrigate any land shall have a lien for payment upon the crops grown thereon.

Any person wilfully injuring any irrigating canal, the right of way having been secured, is guilty of a misdemeanor and may be punished by fine or imprisonment.

MONTANA IRRIGATION LAWS. *

Revised Statutes, 1879, in the fifth division of general laws, Chapter XV, on corporations for industrial or productive purposes, Article I, contains provisions in substance as follows:

SEC. 271. Whenever any three or four persons form a company for constructing a ditch for the purpose of conveying water to mines, mills, or lands, for the use of mining, milling, or irrigation of lands, they shall in their certificate specify as follows: The stream or streams from which the water is taken; the point or place on said stream at or near which the water is to be taken out; the line of said ditch, as near as may be, and the use to which the water is intended to be applied. For other details of certification see section 244.

SEC. 272. Any ditch company shall have the right of way over the line named in the certificate, and the right to run the water of the stream or streams through their ditch: *Provided*, That the proposed line shall not interfere with any other ditch whose rights are prior; the water of any stream shall not be diverted from its original channel to the detriment of any miners or mill-men or others along the line of the stream who have priorority of right.

SEC. 273. Any company constructing a ditch shall furnish water in the way and manner named in the certificate designated to be used, whether miners, mill-men, or farmers, whenever they shall have water in their ditch unsold. They shall give the preference at all times to this class of persons, the rates for furnishing water to be fixed by county commissioners or the tribunal transacting county business as soon as the ditch is completed and prepared to furnish water.

SEC. 274. Every ditch company organized shall keep the banks of their ditch in good condition, so that the water will not escape and injure any mining claim, road, ditch, or other property; and whenever it is necessary to convey any ditch over, across, or above any lode or mining claim the company shall flume the ditch, if necessary, to keep the water out or from any claim, so far as it is necssary to protect the claim or property from the water of the ditch.

SEC. 275. When any company shall organize to form a company to construct a flume, their certificate shall, in addition to details required by previous sections, specify as follows: The place of beginning, termini, and route, as near as may be, and the purpose for which the flume is intended; and when organized, the company shall have the right of way over the line proposed for the flume, provided it does not conflict with the right of any former fluming, ditching, or other company.

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SEC. 279. Any company formed for the purpose of constructing any ditch or flume shall commence work within sixty days from the date of their certificate, and shall prosecute the work with due diligence until the same is completed; the time of completion shall not extend beyond three years from the time the work was commenced; and the company failing to commence work within sixty days of the date of certificate, and failing to complete it within three years of commencement, shall forfeit all right to the route claimed, and it shall be subject to be claimed by any other company.

SEC. 280. Every corporation formed has power, first, to have succession by its corporate name for the period limited in its certificate of charter; second, to sue and be sued, complain and defend in any court of law or equity; third, to make and use a common seal and alter the same at pleasure; fourth, to hold, purchase, and convey such real and personal estate as the purposes of the corporation may require; fifth, to appoint such subordinate officers and agents as the business of the corporation shall require, and to allow them a suitable compensation; sixth, to make by-laws, not inconsistent with any existing law, for the management of its property, the regulation of its affairs, and for the transfer of stock: *Provided*, That no corporation formed shall own or hold possession of more than six hundred and forty acres of land.

* Territorial laws adopted by the State.

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SEC. 281. The powers enumerated in the preceding sections shall vest in any corporation that shall hereafter be created, although they may not be specified in the certificate; but no corporation shall possess or exercise any corporate powers, except such as shall be necessary to the exercise of the powers so enumerated.

SEC. 282. Willful or malicious damages, or interference with property of any kind belonging to any company organized, upon conviction before the county court where the offense is committed, shall be fined not exceeding five hundred dollars, or imprisoned not exceeding one year, or both, and the offender shall pay all damages the corporation may sustain, together with costs of suit.

* * * * * * *

SEC. 285. Whenever any organized company shall not have acquired, by gift or purchase, the right of way required for the construction or maintenance of any road, ditch, telegraph, or flume, or may be affected by the operations of the same, they may present a petition to the probate judge of the county, describing the lands required, giving the name and residence of each owner, and praying for the appointment of appraisers. The judge, having evidence that the owners have been notified ten days previously by publication or notices in some public place in the county, shall appoint three impartial appraisers, who shall take an oath to perform their duties faithfully. Two of them shall review the premises, ascertain and certify the proper compensation to be made, as well as all damages accruing to the owners, after making a just allowance for the real benefits or advantages which the owners may derive from the construction of the road, ditch, telegraph, or flume. They shall file a certificate of their ascertainment and assessment in the county clerk's office. The probate judge upon such certificate and proof that compensation has been paid to the parties entitled to the same, or deposited to their credit, shall have a certified copy of the description of the lands and payment or deposit of compensation recorded in the recorder's office of the proper county. The corporation shall have the exclusive right of all such lands, during the continuance of the corporation, and may take possession of, hold, and use the same for the purpose of the road, ditch, telegraph, or flume, and shall be discharged from all claims for any damage. If at any time after an actual ascertainment of compensation the title acquired or the assessment should be deemed defective, the corporation shall proceed and perfect the title by procuring the assessment of the proper compensation to be made to any person who has an interest in or lien upon the lands. The probate judge may authorize the corporation, if already in possession, to make payment in the manner hereinafter provided; if not in possession to take possession of and use the premises until the final conclusion of the proceedings, and may stay all actions against the corporation on account thereof: *Provided*, That the corporation shall pay a sufficient sum into court, or give approved security to pay the compensation. When possession shall be so authorized it shall be lawful for the owners to conduct the proceedings to a conclusion if the same shall be delayed by the company.

The substance of Article I, Chapter XXXIII, on rights of persons and corporations is as follows:

SEC. 731. Any person or persons, corporation or company, who may have or hold a title or possessory right or title to any agricultural lands as defined by the organic act shall be entitled to the use and enjoyment of the waters of the streams or creeks for the purposes of irrigation, and making the land available for agricultural purposes to the full extent of the soil: *Provided*, That in all cases where, by virtue of prior appropriation, any person may have diverted all the water of any stream, or to such an extent that there shall not be an amount sufficient left for those having a subsequent right for such purpose of irrigation, and there shall at any time be a surplus so diverted, over and above what is actually used for such purpose by prior appropriation, such person shall be required to turn and cause to flow back the surplus water, and upon failure to do so, within five days after demand being made upon him in writing by any person having a right to the use of the surplus water, the person diverting the same shall be liable to the person aggrieved in the sum of twenty-five dollars for each and every day the water shall be withheld after the notice, to be recovered by civic action by any person having a right to the use of the surplus water.

SEC. 732. When any person or persons, corporation or company, owning or holding land shall have no available water facilities, and when it is necessary to raise the waters of the stream or creek to a sufficient height to irrigate the land, or whenever the lands are too far removed from the stream or creek to use the waters, the person or persons, corporation or company, shall have the right of way through and over any tract or piece of land for the purpose of conducting and conveying the water by means of ditches, dikes, flumes, or canals.

SEC. 733. The right to dig and construct ditches, dikes, flumes, and canals over and across the lands of another shall only extend to so much digging, cutting, or excavations as may be necessary for the purposes required.

SEC. 734. In all controversies respecting the rights to water the same shall be determined by the date of the appropriation as respectively made by the parties.

SEC. 735. The waters of the streams or creeks may be made available to the full extent of the capacity for irrigating purposes without regard to deterioration in quality or diminution of quantity, so that the same does not materially affect or impair the rights of the prior appropriator; but in no case shall the same be diverted or turned from the ditches or canals of the appropriator so as to render the same unavailable.

SEC. 736. Any person or persons, corporation or company, damaging or injuring the lands or possessions of another by reason of cutting or digging ditches or canals, or erecting flumes, shall be liable to the party so injured.

SEC. 737. This article shall not be so construed as to impair, or in any way or manner interfere with, the rights of parties to such use of the water of streams or creeks as may have been acquired before its passage.

SEC. 738. This article shall not be so construed as to prevent or exclude the appropriation of the waters of the streams or creeks for mining, manufacturing, or other beneficial purposes, and the right also to appropriate the same is hereby equally recognised and declared.

SEC. 739. Any person or persons, corporation or company, who may dig and construct ditches, dikes, flumes, or canals over or across any public roads or highways, or who may use the waters of the same, shall be required to keep the same in good repair at such crossings or other places where the water may flow over or in any wise injure any roads or highways, either by bridging or otherwise.

SEC. 740. Any person or persons offending against the preceding section on conviction shall pay for every offense not less than $25 nor more than $100, with costs of suits in civil action; one-half the fine shall be paid for the benefit of the common schools of the county, the other half to the person or persons giving the information. The defendant or defendants may be confined in the county jail until the fine and the costs are paid.

SEC. 741. In all controversies respecting the rights to water, whether for mining, manufacturing, agricultural, or other useful purposes, the rights of the parties shall be determined by the dates of appropriation respectively, with the modifications heretofore existing under the local laws, rules, or customs, and decisions of the Supreme Court.

Article II deals with the regulations for the sale of water, and in substance is as follows:

SEC. 742. Any person or persons, corporation or company, having the right to use, sell, or dispose of water, and engaged in using, selling, or disposing of the same, who shall have a surplus not used or sold; or any person or persons, corporation or company having a surplus of water, and the right to sell and dispose of the same, shall, and they or it are hereby required, upon the payment or tender to the person or persons entitled thereto of an amount equal to the usual and customary rates per inch, to convey and deliver to the person or persons, company or corporation, such surplus of unsold water, or so much for which the payment or tender shall have been made, and shall continue so to convey and to deliver the same weekly, so long as the surplus of unused or unsold water shall exist and the payment or tender be made.

SEC. 743. Any person or persons, corporation or company, shall, at their own cost and expense, construct or dig the necessary flumes or ditches to receive and convey the surplus water so desired by it or them, and shall pay or tender to those having a right to the use, sale, or disposal thereof, an amount equal to the necessary costs and expense of tapping any gulch, stream, reservoir, ditch, flume, or aqueduct, and putting in gates, gauges, or other proper and necessary appliances, usual and customary in such cases, and until the same shall be so done the delivery of the surplus water shall not be required.

SEC. 744. Any person or persons, company or corporation, constructing the necessary ditches, aqueducts, or flumes, and making the payments or tenders, shall be entitled to the use of so much of the surplus water as the ditches, aqueducts, or flumes shall have the capacity to carry, and for which payment or tender shall have been made, with all the rights and privileges incidental thereto, so long as the unsold or surplus water exists and the payment or tender shall be or have been made, and may institute and maintain appropriate action, at law or in equity, for the enforcement of such right or recovery of damages arising from a failure to deliver, or wrongful diversion of the same.

SEC. 745. Nothing in this article shall be so construed as to give the person or persons, corporation or company, acquiring the right to the use of water, as hereinbefore provided, the right to sell or dispose of the same after being so used by it or them, or prevent the original owner or proprietor from retaking, selling, and disposing of the same in the usual and customary manner after it is so used.

Chapter XLV, on rights of way for the development of mines, Article IV, in substance is as follows:

SEC. 886. The proprietor, owner, or owners of mining claims, whether patented under the laws of the United States or held under the local laws and customs, shall have a right of way for ingress and egress, for the necessary purposes, over and across

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the lands or mining claims (patented or otherwise) of others, as hereinafter prescribed.

SEC. 887. Whenever any mine or mining claim shall be so situated that it can not be conveniently worked without a road thereto, or a ditch to convey the water thereto, or a ditch or a cut to convey the water therefrom, or without a flume to carry water and tailings therefrom, or without a shaft or tunnel thereto, which road, ditch, cut, flume, shaft, or tunnel shall necessarily pass over, under, through, or across any lands or mining claim owned or occupied by others, either under a patent from the United States or otherwise, then shall the first-mentioned owner or owners be entitled to the right of way for the road, ditch, cut, flume, shaft, or tunnel over, under, through, and across the other lands or mining claims.

SEC. 888. Whenever the owner or owners of any mine or mining claim desire to work the same successfully, he or they shall have the right of way for the purposes heretofore mentioned, and if it shall not have been acquired by agreement between all parties, it shall be lawful for him or them to present a petition to the judge of the district court of the county, praying that the right of way be awarded to him or them. The petition shall be verified and contain a description of the character and extent of the right sought, the mine or claim of the petitioner, and the claim or claims, and the lands to be affected by the right, with the names of the occupants or owners. It may also set forth any tender or offer hereinafter mentioned, and shall demand the relief sought.

SEC. 889. Upon the receipt and filing of the petition with the clerk of the court, the judge shall direct a citation to issue under the seal of the court, to the owners, named in the petition, of the mining claims and lands to be affected by the proceedings, requiring each of them to appear before the judge on a day therein named, which shall not be less than ten days from the service thereof, and show cause why the right of way should not be allowed. The citation shall be served on each of the parties in the manner prescribed by law.

SEC. 890. Upon the return day of the citation, or upon any day to which the hearing shall be adjourned, the judge shall hear the allegations and proofs of the respective parties, and if he is satisfied that the claims of the petitioner can only be conveniently worked by means of the privilege prayed for, he shall make an order adjudging and awarding the right of way, and shall appoint three commissioners, disinterested parties, and residents of the county, to assess the damages resulting to the lands or claims affected by the order.

SEC. 891. The commissioners shall faithfully and impartially proceed to examine the premises and shall assess the damages and report the amount to the judge, and if the right of way shall affect the property of more than one person or company, the report shall contain an assessment of damages to each company or person.

SEC. 892. For good cause shown, the judge may set aside the report of such commissioners and appoint three others, whose duties shall be the same as above mentioned.

SEC. 893. Upon the payment of the sum assessed as damages to the persons to whom it shall be awarded, or a tender thereof to them, then the person or persons petitioning shall be entitled to the right of way, and may immediately proceed to occupy the same, and to erect such works and structures and make such excavations as may be necessary to the use and enjoyment of the right.

SEC. 894. Appeals from the assessment of damages may be made and prosecuted in the proper district court by any party interested, at any time within ten days after the filing of the report, and a written notice of the appeal shall be served upon the appellee. The appellant shall file with the clerk of the court a bond, with sureties to be approved by the clerk, in the amount of the assessment appealed from in favor of the appellee, conditioned that the appellant shall pay any costs that may be awarded to the appellee and abide by any judgmentt hat may be rendered in the cause.

SEC. 895. Appeals shall bring before the appellate court only the propriety of the amount of damages and may be tried by the court or before a jury.

SEC. 896. The prosecution of any appeal shall not hinder, delay, or prevent the appellee from exercising all the rights and privileges heretofore mentioned: *Provided*, That the appellee shall file with the clerk of the court in which the appeal is pending a bond with sufficient sureties, to be approved by the clerk, in double the amount of the assessment appealed from, conditioned that the appellee shall pay to the appellant whatever amount he may recover in the action.

SEC. 897. If the appellant recover $50 more damages than the commissioners shall have awarded, or the appellee shall offer to allow judgment against him to be taken, the appellee shall pay the costs of appeal, otherwise the appellant shall pay such costs.

SEC. 898. The costs and expenses of proceedings, except as herein otherwise provided, shall be paid by the party making the application: *Provided, however*, That if the applicant shall, before the commencement of such proceedings, have tendered to the parties owning or occupying the lands or mining claims a sum equal to or more than the amount of damages recovered by the defendant or defendants, then all

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of the costs and expenses shall be paid by the party or parties owning the lands or mining claims affected by the right of way and who appealed and resisted the claim of the applicants.

The substance of Article I, section 1081 (Chapter LIV, on roads and highways), is as follows: County roads running parallel shall not be nearer than one mile, and upon the presentation of a petition signed by at least five freeholders of any neighborhood praying for passage to the various water-courses for stock purposes, the commissioners may at their discretion establish such passage-way. This section shall also apply to the opening and establishment of neighborhood roads running to timber.

(For other details of roads, see section 1064.)

The general laws for 1883 contain an act to punish persons for unlawfully diverting water; in substance it is as follows:

SECTION. 1. Any person who shall divert from any water-course or ditch any water flowing therein, and by such diversion shall deprive another of the use of water to which he is entitled by law, and who shall refuse immediately to relinquish the water so diverted, upon demand being made by the person, or the agent of the person, to whom the water rightfully belongs, shall, on conviction, be fined in any sum not to exceed $100 or imprisoned in the county jail not exceeding three months, or by both.

SEC. 2. If any person, by force, threats, intimidation, or putting in fear with arms, or otherwise, near or upon any water-course or ditch, shall prevent or seek to prevent any person from possessing or obtaining any water which he desires for some useful purpose, or by these means shall prevent any person lawfully entitled to the use thereof from diverting the water, when and where he may desire, the person so offending shall be deemed guilty of felony, and on conviction, be imprisoned in the Territorial prison not less than one year, nor more than five years.

The general laws of 1885 contain an act relative to water-rights, in substance as follows:

SECTION 1. The right to the use of running water flowing in the rivers, streams, cañons, and ravines may be acquired by appropriation.

SEC. 2. The appropriation must be for some useful or beneficial purpose, and when the appropriator or his successor in interest abandons and ceases to use the water for such purposes the right ceases; but questions of abandonment shall be questions of fact, and shall be determined as other questions of fact.

SEC. 3. The person entitled to the use of water may change the place of diversion, if others are not thereby injured, and may extend the ditch, flume, pipe, or aqueduct, by which the diversion is made, to any place other than where the first use was made, and may use the water for other purposes than that for which it was originally appropriated.

SEC. 4. The water appropriated may be turned into the channel of another stream and mingled with its waters, and then [be] reclaimed; but in reclaiming it water already appropriated by another must not be diminished in quantity or deteriorated in quality.

SEC. 5. As between appropriators, the one first in time is first in right.

SEC. 6. Any person hereafter desiring to appropriate water must post a notice in writing in a conspicuous place at the point of intended diversion, stating first, the number of inches claimed, measured as hereinafter provided; second, the purpose for which it is claimed, and place of intended use; third, the means of diversion, with size of flume, ditch, pipe, or aqueduct, in which he intends to divert it; fourth, the date of appropriation; fifth, the name of the appropriator. The appropriator shall file with the recorder of the county, within twenty days after date of appropriation, a notice, which, in addition to the facts required to be stated in the posted notice, shall contain the name of the stream from which the diversion is made, if it has a name, and if not, such a description of it as will identify it; also an accurate description of the point of diversion and reference to some natural object or permanent monument.

The recorded notice shall be verified by the affidavit of the appropriator, or some one in his behalf, which must state that the matter and things contained in the notice are true.

SEC. 7. Within forty days after posting the notice the appropriator must proceed to prosecute the excavation or construction of the work by which the water appropriated is to be diverted, and must prosecute the same with reasonable diligence to completion. If the ditch or flume, when constructed, is inadequate to convey the amount of water claimed, the excess claimed above the capacity of the ditch or flume shall be subject to appropriation by any other person.

SEC. 8. A failure to comply with the provisions of this act deprives the appropriator of the right to the use of water as against a subsequent claimant who complies therewith, but by complying the right to the use of the water shall relate back to the date of posting notice.

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SEC. 9. Persons who have heretofore acquired rights to the use of water shall, within six months after the publication of this act, file in the recorder's office of the county wherein the water-right is situated a declaration in writing, except notice be given of record setting forth the same facts required in the notice provided for in section 6 of this act. The declaration shall be verified as before required in cases of notice of appropriation of water: *Provided*, That a failure to comply with the requirements of this section may in no wise work a forfeiture of such heretofore acquired rights, nor prevent any such claimant from establishing such rights in the courts.

SEC. 10. The record provided for in the preceding sections, when duly made, shall be taken and received in all the courts as prima facie evidence of the statements therein obtained.

SEC. 11. In any suit hereafter commenced for the protection of rights acquired to water, the plaintiff may make any or all persons who have diverted water from the same stream or source parties to such action, and the court may in one decree settle the relative priorities and rights of the parties to such suit. When damages are claimed for the wrongful diversion of water, the same may be assessed and apportioned by the jury in their verdicts, and judgment may be entered for or against one or more of several defendants, and may determine the ultimate rights of parties between themselves.

SEC. 12. In any action concerning joint water-right, or joint rights in water-ditches, unless partition of the same is asked by parties to the action, the court shall hear and determine such controversy as if the same were several as well as joint.

SEC. 13. The recorder of each county must keep a well-bound book, in which he must record the notices and declarations provided for in this act, and he shall be entitled to have and receive the same fees as are now or hereafter may be allowed by law for recording instruments entitled to be recorded.

SEC. 14. The measurement of water appropriated shall be conducted in the following manner: A box or flume shall be constructed, with a head-gate placed so as to leave an opening of 6 inches between the bottom of the box or flume and lower edge of the head-gate, with a slide to enter at one side of and of sufficient width to close the opening left by the head-gate, by means of which the dimensions of the opening are to be adjusted. The box or flume shall be placed level, and so arranged that the stream in passing through the aperture is not obstructed by backwater or an eddy below the gate; but before entering the opening to be measured the stream shall be brought to an eddy, and shall stand three inches on the head-gate and above the top of the opening. The number of square inches contained in the opening shall be the measure of inches of water.

NEBRASKA LAW.

Irrigation companies may be incorporated under general laws, and are declared to be works of internal improvement, and, as such, towns may vote gratuities to them to the extent of 10 per cent. of the assessed value of such towns, and by a two-thirds vote to the extent of 15 per cent., and may issue bonds for the same purpose to the amount of 10 per cent. of the assessed value.

NEVADA IRRIGATION LAWS.

AN ACT TO REGULATE THE USE OF WATER FOR IRRIGATION AND FOR OTHER PURPOSES, ETC.

SECTION 1. That the lands now irrigated, or which may hereafter be irrigated in the State of Nevada, are hereby divided into the following irrigation districts: District No. 1 shall consist of all the lands irrigated from the Truckee River and its tributaries. District No. 2 shall consist of all the lands irrigated from the Carson River and its tributaries. District No. 3 shall consist of all the lands irrigated from the East and West Walker Rivers and their tributaries. District No. 4 shall consist of all the lands irrigated from the Humboldt River and its tributaries. District No. 5 shall consist of all the lands irrigated from the Owyhee River and its tributaries. District No. 6 shall consist of all the lands irrigated from the Rees River and its tributaries. District No. 7 shall consist of all the lands irrigated from the White River and its tributaries. District No. 8 shall consist of all the lands irrigated from the Muddy River and its tributaries. Other irrigation districts may be formed from time to time by the governor, on petition of the parties interested, comprising territory not within any of the above-established irrigation districts.

SEC. 2. There shall be one water commissioner for each of the above-named districts and for each district hereafter formed, who shall be appointed by the governor whenever his service may be required, to be selected by him from the persons recom-

mended to him by the several boards of county commissioners of the counties in which the water districts may extend, and the water commissioners so appointed shall hold office for the period of two years, or until their successor is appointed and qualified. The governor, by like selection and appointment, shall fill all vacancies which may be caused by death, resignation, or continued absence from the district, removal or otherwise, and the governor may at any time remove any water commissioner for failure to perform his duties or for any other cause.

SEC. 3. That within twenty days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe to an oath to faithfully and impartially perform the duties of his office, which oath shall be deposited with the clerk of the court having jurisdiction over his district.

SEC. 4. It shall be the duty of said water commissioners to divide the water in the natural lakes or streams of their districts among the several ditches taking water from the same according to the prior rights of each, respectively, in whole or in part, and to shut and fasten, or cause to be shut and fastened, the head-gates of any ditch or ditches heading in any of the natural streams or lakes of the district, which in time of a scarcity of water makes it necessary by reason of the priority of the rights of others above or below them on the stream.

SEC. 5. Every person who shall willfully open, close, change, or interfere with any head-gate or water-box without authority shall be guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not exceeding five hundred dollars, or imprisoned in the county jail for a term not exceeding six months, or both such fine and imprisonment. The water commissioners, or their assistants, within their districts, shall have authority to arrest any person or persons offending, and take them before the nearest justice of peace in the county, to be dealt with as in other cases.

SEC. 6. The water commissioner herein provided shall be entitled to pay at the rate of five dollars per day for each day he shall be actually employed in the duties of his office, not to exceed ninety days in any one year, to be paid by the county in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of county commissioners of the county in which his district may be, and said board of county commissioners shall allow and pay the same out of the county treasury, and where irrigation districts shall extend into two or more counties then said water commissioner shall be paid for his services as follows: In District No. 2, Douglas County shall pay ——, Ormsy County shall pay ——, Lyon County shall pay ——, Churchill County shall pay ——. In District No. 3, Esmeralda County shall pay ——, Lyon County shall pay ——, Douglas County shall pay ——. In District No. 4, Humboldt County shall pay three-sevenths ——, Lander County shall pay one-quarter ——, Eureka County shall pay one-quarter ——, Echo County shall pay three-sevenths ——. District No. 6, Lander County shall pay ——, Nye County shall pay ——. Said water commissioner shall have power, in case of emergency, to employ suitable assistants to aid him in the discharge of his duties; such assistants shall take the same oath as the water commissioner and shall obey his instructions, and each shall be entitled to four dollars per day for every day he is actually employed, not to exceed thirty-five days in any one year, to be paid upon the certificate of the water commissioner in the same manner as is provided for payment of water commissioners.

SEC. 7. Said water commissioners shall not begin their work until they shall be called by three or more owners or managers or persons controlling ditches in their several districts by application in writing, stating that there is a necessity for their action, and they shall not continue performing services after the necessity therefor shall cease.

SEC. 8. For the purpose of hearing, adjudicating, and settling all questions concerning the propriety of the appropriation of water between ditch companies and other owners of ditches drawing water for beneficial purposes from the same stream or its tributaries or lakes, within the same irrigation district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested exclusively in the several district courts as follows: For district No. 1, in the district court of the State of Nevada, Washoe County; for district No. 2, in the district court of the State of Nevada, Ormsby County; for district No. 3, in the district court of the State of Nevada; for district No. 4, in the district court of the State of Nevada, for either Humbolt or Elko Counties; for district No. 5, in the district court of the State of Nevada; for district No. 6, in the district court of the State of Nevada, Lander County; for district No. 7, in the district court of the State of Nevada; for district No. 8, in the district court of the State of Nevada. All lakes, streams, and reservoirs not herein enumerated shall be for all purposes attached to and belong to the irrigation district in which the greater portion of its waters is, it being the intention and meaning hereof to add to each irrigation district all waters not hereinbefore enumerated, the majority of which lie within their re-

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spective areas, for the purpose of acquiring rights to the appropriation and use thereof and adjudicating the same.

SEC. 9. In order that all parties may be protected in their lawful rights to the use of water for beneficial purposes, every person, association, or corporation owning or claiming any interest in any ditch, canal, or reservoir within any water district shall, on or before the first day of September, eighteen hundred and eighty-nine, file with the county recorder of the county a statement of their claim under oath, entitled of the proper county, which statement shall contain the name or names, together with the post-office address, of the claimant or claimants claiming ownership as aforesaid of any such ditch, canal, or reservoir, the name thereof (if any), and if without a name the owner or owners shall choose and adopt a name to be therein stated by which such ditch, canal, or reservoir shall thereafter be known; the description of such ditch, canal, or reservoir as to location of head-gate, general course of ditch, the name of the natural stream or lake from which such ditch, canal, or reservoir draws its supply of water; the length, breadth, depth, and grade thereof as near as may be; the time, fixing a day, month, and year as the date of appropriation of water by original construction, also by the enlargement or extension, if any such thereof have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder of reservoir, and also the number of acres of land lying under and being, or proposed to be, irrigated by water from such ditch, canal, or reservoir; or if such waters have been appropriated for other beneficial purposes than irrigation, a statement of such purposes. Said statement shall be signed by the proper party or parties and filed with the recorder of the county wherein the right claimed is situated, which shall be recorded by him in a book kept for that purpose.

SEC. 10. Upon the filing of such statement the recorder shall indorse upon the back thereof the date of filing, and shall prepare an index of the same in a book to be provided for that purpose by the county commissioners, which said index shall contain the date of filing, the name of the party, association, or corporation, the name of the ditch, the stream from which the water is taken by such ditch, canal, or reservoir, the location of the head-gate, the date of the appropriation of the water by construction, enlargement or extension. Said index shall be prepared alphabetically by reference to the name of the ditch, canal, or reservoir.

SEC. 11. For filing and indexing such statement the recorder shall receive the same fees as for recording deeds, to be paid by the party or parties filing the same.

SEC. 12. That hereafter every person, company, or corporation constructing, enlarging, or extending any ditch, canal, or reservoir for beneficial purposes, and intending to use or appropriate any water from any natural stream or lake within any water district for such beneficial purposes, shall file with the county recorder of the proper county before the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, a statement showing the stream or streams from which the water is to be taken; the point or place on said stream at or near which the water is to be taken out; the line or commencement of said ditch or ditches as near as may be; the use or uses to which said water is to be applied; the dimensions of said ditch or ditches, and each thereof, giving width on bottom and top, slope of banks, and grade of ditch, and likewise of any and all enlargements thereof, which statement shall be filed and indexed as is provided in section 9 of this act; and from the time of filing any such statement water sufficient to fill such ditch or ditches and subserve the use or uses aforesaid, if a lawful and just use, shall be deemed and adjudged appropriated: *Provided*, That nothing herein contained shall be permitted to interfere with a prior right to said water or to any thereof: *And provided further*, That such person or persons or corporation shall, within sixty days next ensuing the filing of such statement, begin the actual construction of said ditch or ditches, and shall prosecute the work of the construction thereof diligently and continuously to its completion: *And provided further*, That the beginning of all necessary survey of such ditch or ditches shall be construed as the beginning of said work of construction.

SEC. 13. The water of every natural stream not heretofore appropriated within this State is hereby declared to be the property of the public, and the same is dedicated to the use of the people, subject to appropriation as herein provided. The provisions of this act shall apply to all cases where the water of natural streams or lakes is appropriated for beneficial purposes, whether the water be conducted through ditches, canals, flumes, or tunnels, and shall apply also to cases where for irrigating purposes the water is stored in reservoirs, and the owner or owners of any ditch, canal, flume, or tunnel through which water is conducted for irrigating purposes, and also the owners of reservoirs, may conduct the water therefrom into and along any of the natural streams of the State, but not so as to raise the waters thereof above high-water mark, and may take the same out again at any point desired; but due allowance shall be made for evaporation and seepage, the amount to be determined by the water commissioner of the proper district, subject to review and determination by the court having jurisdiction over priorities in such districts.

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SEC. 14. Whenever any person or persons, association or corporation, interested as owners of any ditch, canal, or reservoir in any district, shall desire a determination of the priorities of rights to the use of water from any stream or streams from which they draw the water for their ditch or ditches, canals, or reservoirs, they shall present to the district court having jurisdiction over the rights in such water district, or to the judge thereof, a petition or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to use of the water for irrigation, between the several ditches, canals, or reservoirs, in such district, on the stream or streams named in such motion, petition, or application. The said motion, petition, or application shall state the names of the ditches, canals, or reservoirs claiming water from said stream or streams as appears from the final statements in the recorder's office, together with the names of the persons, associations, or corporations interested therein, taken from such statements, and shall set forth the nature of the claim or claims of the applicant or applicants, and such motion, petition, or application shall be entitled "In the matter of an application for an adjudication of the priorities of rights to use water for beneficial purposes in water districts. District No. ——, on ——" (stating the stream or streams). Upon the filing and docketing of such application the court or judge thereof shall, without unnecessary delay, by an order to be entered of record upon such petition or application, appoint a day for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court or judge thereof to proceed and hear all evidence that may be offered by or in behalf of any person, association, or corporation interested in stream or streams in such district, in any ditch, canal, or reservoir, either as owner or consumer of water therefrom, in support of or against any claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by any enlargement or extension thereof in such district, or on such stream or streams, and consider all such evidence, also the arguments of the parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof as originally constructed; the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned; the time spent severally in such construction, enlargement, or extension, and re-enlargement, if any; the diligence with which the work was in each case prosecuted; the nature of the work as to the difficulty of construction, and all such other facts as may tend to show the compliance with the law in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right, by appropriation of water of the several ditches, canals, and reservoirs in such water district in such stream or streams, concerning which testimony shall have been offered, each according to the time of its said construction and enlargements and extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargement or extensions, describing such amount by cubic feet per second of time (which shall also be the measurement for the sale of water), if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir. In such decree such court or judge thereof shall receive from the clerk, on payment therefor, a certificate, under seal of the court, showing date or dates and amount or amounts of appropriations adjudged in favor of such ditch, canal, or reservoir, under and by virtue of the construction, extension, and enlargement thereof severally, also specifying the number of said ditch, as determined by said court, with reference to priority and of each priority to which the same may be entitled by reason of said construction, extension, and enlargements; provided, that any party or parties claiming any right to the use of water for beneficial purposes in such district and on such stream or streams by reason of being owner of or interested in any ditch, canal, or reservoir, who is not mentioned in the petition or application, and shall become parties to such proceedings and shall have their rights adjudicated therein. The court, or judge thereof, may, instead of taking testimony orally or in open court, refer the matter to a referee, with such powers as in other cases. The testimony may be taken at any place ordered by the court, or judge thereof, or by the referee.

SEC. 15. The holder of the certificate provided for in section fourteen shall exhibit the same to the water commissioner of the district when he commences the exercise of his duties, and such water commissioner shall keep a book in which he shall enter a brief statement of the contents of such certificate and which shall be delivered to his successor, and said certificate, or statement thereof in his book, shall be the warrant of authority to said commissioner for regulating the flow of water in relation to such ditch, canal, or reservoir; said certificate shall be recorded at the same rates of charges as in case of deeds of conveyance in the records of each county into which the ditch, canal, or reservoir, to which such certificate relates, shall extend; and said

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certificate, or said record thereof, or a duly certified copy of such record, shall be prima facie evidence of so much of the decree as shall be recited therein in any suit or proceeding in which the same may be relevant.

SEC. 16. Upon the order of the court fixing the time of such hearing being made, the clerk shall make a certified copy of such order, which order shall contain the names of all parties alleged in the application to be interested in the matter, which shall be thereupon served upon each of the parties therein named, in the same manner as summons. It shall be the duty of the clerk also to give public notice of such application in a newspaper, if any printed and in circulation, in each county wherein such water district is situated, which shall be published at least twenty days, and which said notice shall contain the date of the filing of said petition or application, the name or names of the parties filing the same, a copy of the order made by the court of hearing, and shall notify all parties interested as owners in any ditch, canal, or reservoir, on such stream or streams, in such water district, as well as the persons named in the petition or application, to appear at said court, or before the judge thereof, at the time appointed and stated in the order; and all persons interested as owners or consumers may then and there present his or her or their proofs for or against any priority of right of water by appropriation sought to be shown by any party, by or through any ditch, canal, or reservoir (either as owner or consumer of water therefrom), and in case any party mentioned in the petition or application can not be personally served in any county embraced in such water district, the published notices above provided shall be deemed sufficient service of notice: *Provided further*, That in addition to such publication the clerk shall mail such published notice to each party mentioned in the petition or application, directing the same to the address of the parties, as stated in the sworn statement on file. Proof of the proper publication shall consist in the sworn certificate of the publisher of the paper in which notice is published, to which shall be attached a printed copy taken from such paper.

SEC. 17. Any person or persons who shall willfully cut, dig, or break down or open any gate, bank, or embankment or side of any ditch, canal, or reservoir, flume, pipe, tunnel, or feeder in which such person or persons may be joint owners or which is the property of another or in the lawful possession of another or others and used for the purpose of irrigation, milling, manufacturing, mining, or domestic purposes, with intent maliciously to injure any person, association, or corporation, or for his or her own gain or with the intention of stealing, taking, or causing to run or pour out of such canal or reservoir, feeder, pipe, or flume any water for his or her own profit, benefit, or advantage, or to the injury of any other person, persons, association, or corporation lawfully in the use of such water or of such ditch, canal, tunnel, feeder, pipe, or flume, he, she, it, or they so offending shall be deemed guilty of a misdemeanor and on conviction thereof shall be fined in any sum not exceeding $500, and may be imprisoned in the county jail not exceeding six months, or both, at the discretion of the court.

SEC. 18. Any party or parties representing any ditch, canal, or reservoir, or any number of parties representing two or more ditches, canals, or reservoirs, which are affected, in common with each other, by any portion of the decree rendered by the district court, by which he, she, it, or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining desiring an appeal shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common adversely to the interest of appellants shall be appellees. The party or parties in such appeal shall, within sixty days after the date of the decree is entered under this act, file a notice of appeal in writing stating that such party or parties appeal to the supreme court of the State from the decree rendered in the case or any part thereof. When only a part of the decree is appealed from, the notice of the appeal shall so state and shall also in that case specify the portion or part of the decree appealed from. Upon filing of such notice of appeal the cause shall be deemed to be appealed to the supreme court of the State: *Provided, however*, That the party or parties appealing as aforesaid shall, within sixty days as aforesaid, enter into an understanding to be approved by the district court, or judge thereof, and to be given to all parties in said suit or proceedings other than the parties appealing, and to be in such an amount as the court or said judge shall order, conditioned that the parties giving the said undertaking shall prosecute their appeal to effect and without unnecessary delay, and will pay all costs and damages which the parties to whom the undertaking is given, or either or any of them, may sustain in consequence of such appeal.

SEC. 19. The notice last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the parties or their attorneys, if they have one, as in other cases.

SEC. 20. The appellant or appellants shall, within six months after the appeal be allowed as aforesaid, file in the office of the clerk of the supreme court of the State a certified transcript of the proceedings had in the case in the district court, contain-

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ing the pleadings and the statements of the parties filed therein and all evidence of record offered on the hearing of the cause, or so much thereof as shall affect the appropriation of water claimed by the means of construction, enlargement, or re-enlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal; such statement to be served, filed, and settled in the same manner as statements on motion for new trials.

SEC. 21. The supreme court in all cases heard before it under this act shall, when it can properly be done, render such decree as the court or judge below should have rendered. It may either reverse or modify the decree of the court below. If reversed in whole or in part it may direct the court below as to its further proceedings therein.

SEC. 22. No claim of priority of any person, association, or corporation, on account of any ditch, canal, or reservoir, as to which he, she, it, or they have filed or refuse to offer evidence under any adjudication herein provided for, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have, by application to the court having jurisdiction, obtained leave therefor and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which shall only be granted upon terms as to notice to other parties interested, and upon payment of all costs, and upon affidavit or petition, sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof, against which such priority is claimed, nor until a decree adjudging such ditch, canal, or reservoir has been entered, and certificate, such as mentioned in section fifteen thereof, shall have been issued to claimant and presented to the water commissioner.

SEC. 23. No person, association, or corporation representing any ditch, canal, or reservoir shall be permitted to give or offer any evidence before said court until he, she, it, or they shall have filed a statement of a claim, in substance the same in all respects as is required to be filed under the provisions thereof.

SEC. 24. The district court or judge thereof shall have power to order, for good cause shown, upon terms just to all parties, and in such manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this act, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved that the ends of justice will thereby be promoted, but no such review or re-argument shall be ordered unless applied for by petition or otherwise within one year of the time of entering the decree complained of.

SEC. 25. Persons desiring to construct and maintain reservoirs for the purpose of toring water shall have the right to take from any of the natural streams of the State and store away any unappropriated water not needed for immediate use, for domestic irrigation, or other needful purposes; to construct and maintain ditches, canals, flumes, and tunnels in the same manner provided by law for the condemnation of lands for right of way for ditches, provided no reservoir with embankment or a dam exceeding 10 feet in height shall be made without submitting the plans thereof to the county commissioners of the county in which it is situated and obtain their approval of said plans.

SEC. 26. The owners of reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by the breaking of the embankment of such reservoir.

SEC. 27. Every witness who shall attend before the court or judge thereof, or before the person appointed to take testimony, in the causes provided for in this act, under subpœna by request of any party, shall be entitled to the same fees and mileage as witnesses in civil cases in the district court, and shall be paid by the party requiring his testimony. All other costs of the proceeding shall be paid by the parties claiming water, as may be adjudged by the court or judge.

SEC. 28. Whenever, in actions for proceedings, for the determination of water rights, it may become necessary to divide the water of any stream or ditch between the different claimants, it shall be divided, as far as possible, by periods of time, instead of fractional parts of the water.

SEC. 29. Said water commissioners shall so divide, regulate, and control the use of the water of all streams within their respective districts in such manner, as near as may be, as will prevent unnecessary waste of water; and to that end such commissioners shall so shut and fasten the head-gate or gates of all ditches so that no more water will flow into said ditch than is actually required and will be used for the purpose or purposes for which such water was appropriated; and any person may resort to any court of competent jurisdiction for such relief as he may be entitled to.

SEC. 30. Whenever testimony shall or may be taken in any district created by this act for the purpose of procuring decree as to appropriation of water and priorities thereof, any testimony theretofore taken upon the hearing of any former application or petition under this act may be introduced and shall be received as evidence.

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SEC. 31. This act shall in nowise be construed as impairing or abridging any rights already vested in any person or persons, company or corporation, by virtue of the law heretofore.

SEC. 32. All acts and parts of acts inconsistent with this act are hereby repealed.

SEC. 33. This act shall take effect and be in force from and after its passage.

UNLAWFUL DIVERSION AND WASTE OF WATER.

SECTION 1. Any person or persons who shall, during the irrigating season, divert and conduct the water, or portion thereof, of any river, creek, or stream into a slough or sloughs, dam or dams, pond or ponds, and retain, or cause the same to be held or retained therein without making any other use of such water, or who shall, during the irrigating season, divert and conduct the water, or portion thereof, away from any such river, creek, or stream, and run, or cause or allow the same to run to waste on sage-brush or greasewood land, such diversion shall be deemed an unlawful use and waste of water.

SEC. 2. Any person or persons, company, corporation, or association who shall, during the irrigating season, divert and conduct, or any person or persons aiding, abetting, or assisting any such person or persons, company, corporation, or association in diverting and conducting, during the irrigating season, the water, or portion thereof, of any river, creek, or stream into any slough or sloughs, dam or dams, or pond or ponds, and retain, or cause the same to be retained therein without making any other use of such water, or who shall, during the irrigating season, divert and conduct the water, or portion thereof, away from any river, creek, or stream, and run, or cause or allow the same to run to waste, contrary to and in violation of the provisions of this act, shall be guilty of a misdemeanor, and upon conviction thereof, in any court of competent jurisdiction in this State, shall be punished by a fine not exceeding five hundred dollars or by imprisonment in the county jail of the county not exceeding six months, or by both such fine and imprisonment.

Approved February 28, 1889.

RECLAMATION COMMISSION.

Whereas the State of Nevada has received from the General Government a grant of two million acres of land in lieu of the sixteenth and thirty-sixth sections, previously granted to the State of Nevada, the proceeds from the sale of which are to be placed to the credit of the school fund of the State; and

Whereas under an act of Congress approved September 4, 1841, and an act approved March 21, 1864, a grant of 500,000 acres of land was made to the State of Nevada for internal improvements; and

Whereas the selections of said lands are not confined to any particular section of unappropriated land; and

Whereas the greater portion of unappropriated lands in the State of Nevada is known to be desert, waste, and actually valueless and without sale, unless water, for the purpose of irrigation, can be brought upon them, and the land properly and systematically irrigated, crops of all kinds can not be successfully raised; and

Whereas the permanent settlement, growth, wealth, and independence of the State and people, as well as the sale of school lands, depend upon the reclamation of these desert lands: Now, therefore,

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. A board of reclamation commissioners is hereby created, to consist of four members, to be known as the "board of reclamation and internal improvements," for the storage of water and reclamation of arable desert lands in this State. Said board to consist of J. F. Clark, of Humboldt County, Evan Williams, of Ormsby County; J. R. Bradley, of Elko County, and Herman Springmeyer, of Douglas County. The said J. F. Clark, of Humboldt County, and Evan Williams of Ormsby County, to hold the position for the term of four years, or until the election of their successors, and the said J. R. Bradley, of Elko County, and Herman Springmeyer, of Douglas County, to hold the position for the term of two years, or until the election of their successors. The State of Nevada is hereby divided into seven internal improvement and reclamation districts, of which Douglas, Ormsby, Esmeralda, Lyon, and Storey, shall constitute the first district, Washoe County, the second district, Churchill County, the third district, Humboldt County, the fourth district, Elko County, the fifth district, Lander, Eureka, and White Pine Counties, the sixth district, and Nye and Lincoln Counties the seventh district. At the general election in eighteen hundred and ninety, and at each general election thereafter, there shall be elected from the State at large two reclamation commissioners, one who shall serve for the term of two years, and one for the term of four years, from and after the first Monday in January next succeeding such election.

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The office of said board shall be in the State capitol building, at the seat of government. The board shall adopt rules and regulations for the transaction of its business.

SEC. 2. The board of reclamation shall invite, receive, and procure information and statistics in regard to all public lands within this State, and the waters running therein, which are or may become possible of reclamation, by means of conducting upon them the unappropriated waters running through natural or artificial channels within this State, and shall report the same, together with an approximate estimate of costs and result of such proposed reclamation, at each biennial session of the legislature.

SEC. 3. The board of reclamation shall also invite, receive, procure, and publish facts and statistics regarding the natural water-courses of this State and several districts, including source, supply, water-power, and other matters relating to the value of said waters, or the most practical methods of utilizing the same, either for milling, mining, manufacturing, or agricultural purposes, in order that said information may be offered for the attraction of dormant capital and the encouragement of individual enterprise.

SEC. 4. It shall be the duty of the surveyor-general, *ex officio*, to furnish the board of reclamation, within a reasonable time, maps, profiles, and estimates to determine the cheapest and most economical and valuable routes for canals, reservoirs, and other improvements for irrigation and milling purposes; and also to furnish maps, plans, and estimates for the purpose of building reservoirs, dams, etc., connected with the storing and preserving of waste water.

SEC. 5. The board of reclamation shall have the power to divide the State into districts, and to appoint a superintendent for each reclamation district within the State, which they may establish and refine, whose duty it shall be to superintend the building, constructing, and maintenance of the canals, dams, and other like works within his district as so defined.

SEC. 6. The work of building and constructing any and all canals, dams, and other improvements shall be done by contract, if done by private parties the contracts to be let to the lowest responsible bidder. The work done by contract shall be let in lots of one or more sections, said sections not being more than one mile in length, as indicated by the maps, profiles, plans, and specifications prepared by the surveyor-general and adopted by said board.

SEC. 7. The board of reclamation commissioners, of the State are hereby authorized and directed to employ a competent civil engineer to ascertain and report the number of irrigating ditches in each reclamation district, the capacity of the same in inches, and amount heretofore appropriated and used through said ditches.

SEC. 8. Any irrigating ditch now constructed and hereafter carrying more water than reported by said civil engineer, the owner or owners thereof of said ditch shall pay to the reclamation fund of the State, for such additional water, such sums or rates as the board of reclamation commissioners shall designate; which sum so paid shall constitute a part of the reclamation fund, and shall be available for demands against said fund.

SEC. 9. Whenever the board of reclamation commissioners deem the reorganization or division of any district advisable for internal improvements contemplated by this act, they shall have power to make such changes and establish such additional rules for the government thereof as will not conflict with prior rights as now recognized by law.

SEC. 10. The board shall have power to purchase or rent such lands for reservoirs, sites, or ditches, as they may deem best, whether within or without the boundaries of this State.

SEC. 11. The board of reclamation commissioners, on petition of ten or more persons interested in irrigation ditches in any district in this State petitioning for the issuance of bonds of said district for reclamation purposes, said board shall, at the next general election, submit the question, together with amount of bonds to be issued, to the voters of said district; and, if carried at said election, the said board shall issue and dispose of said bonds under such rules and regulations as they may adopt, the proceeds thereof to be placed in the reclamation fund of the district, and made available for reclamation purposes.

SEC. 12. The board shall advertise for and receive bids upon the work to be done as soon as the surveyor-general can have surveys, maps, plans, specifications, and estimates of the same in readiness for adoption by the board and inspection by bidders, and shall fix a time when they will open bids and award contracts, which shall not be done on less than four weeks' notice thereof, which said notice shall be given for said time by publication in one newspaper in the reclamation district where the work is to be done, or by posting notices.

SEC. 13. The terms of contracting may be to pay monthly, as the work progresses, on the estimate of the surveyor-general or engineer of the amount of work done, seventy per centum of its contract value, reserving to the district or State thirty per

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centum of the value thereof to insure its faithful completion according to contract, when full payment shall be made, including the retained per centum.

SEC. 14. The board shall fix a definite day for the final completion of any canal, dam, or other improvement, and require all contracts to be done and completed on or before that day, and shall in any agreement reserve the right of forfeiture to the State or district of any retained per centum, and to award the contract of any person or persons who, in the opinion of the surveyor-general, confirmed by the board, fails to make such monthly progress as will insure the completion of any such work so undertaken or contracted for on the day named.

SEC. 15. The board of reclamation shall, upon organization as herein provided, be authorized, empowered, and directed to construct a canal, ditch, or other proper work at, from, or upon the most desirable and practical point on any river or water-way in the State, or that can be procured—the said point to be hereafter selected by said board—to connect with, and to be connected with, for the purpose of milling or irrigating the arable lands situate, lying, and being in the accessible vicinity of such selected river or water-way; and the said canal, ditch, or other work shall be built or established upon a grade or plan in accordance with the configuration and necessities of the shortest and most feasible route and safe carriage of the requisite volume of water required to irrigate the lands within the scope of said ditch or work.

SEC. 16. The total cost of said canal, ditch, or work shall not exceed one hundred thousand dollars, and the cost thereof is hereby limited to that sum.

SEC. 17. The board of reclamation shall audit and certify to the State board of examiners the several amounts that may become due from time to time for work and labor done, services or material furnished in and about the location and building of canals and other works of reclamation that may be carried on, built, and completed under the board, and when approved by the State board of examiners, the controller shall audit the same and draw his warrant upon the State treasurer for the several amounts of such claims, to be paid out of the reclamation fund of the State or district.

SEC. 18. The elective members of the board shall be paid their necessary traveling expenses, and they shall receive no other compensation for their personal services.

SEC. 19. It shall be unlawful for any State officer, or any member of the board of reclamation, to be interested, directly or indirectly, or to take or have any interest or profit, in any manner, in any work of constructing any canal or other improvement for reclamation under this act, and upon conviction shall be fined in any sum not less than one thousand dollars nor more than ten thousand dollars, or imprisonment in the State prison not less than one year nor more than five years, or both such fine and imprisonment.

SEC. 20. The annual rent for water within the scope of any canal, ditch, or work created and built by the board of reclamation shall be one dollar per acre per year. Said rental of water shall be held as a lien against said lands.

SEC. 21. The annual rent of water shall be collected in the same manner and by the same officers as taxes are now collected, and paid into the State or district treasury without fee or abatement and accounted for as the water rent, and placed to the credit of the reclamation and internal improvement fund; and it is hereby enacted that all lands sold by the State under the provisions of this act shall be supplied with the necessary water for reclamation whenever in the judgment of the board it is practicable to do so, and the right of way for the secondary ditches is hereby reserved by the State, and shall be reserved and excepted by the surveyor-general and State land register, from every patent issued by the State, to take up, convey, and deliver all waste water over and across any lands sold and conveyed by the State to any person or persons.

SEC. 22. One hundred thousand dollars is hereby appropriated for the construction and building of any canal, ditch, dam, or other work or works mentioned in this act, and in no case shall a contract or contracts be entered into that shall in the aggregate exceed the sum of one hundred thousand dollars for the construction and building of said canal or work.

SEC. 23. The money herein appropriated shall be taken from the State school fund and placed to the credit of the reclamation fund, herein credited, and in its place shall be deposited one hundred bonds of one thousand dollars each, bearing interest at the rate of four per cent. per annum. Said bonds shall run for twenty years, but shall be redeemable by the State at its pleasure after two years. Said bonds shall be signed by the governor and State controller, and countersigned by the State treasurer, and authenticated with the great seal of the State, and shall state in substance that the State of Nevada owes to its school fund one thousand dollars, the interest on which sum, at four per cent. per annum, it agrees to pay until said bond is redeemed for the benefit of the common schools of the State. Said bonds shall be lithographed, as is usual in such cases, and deposited with the treasurer of the State. The interest on said bonds shall be paid semi-annually, on the first day of January and July, on the written order of the State board of education to the State controller, directing him to draw his warrant for the amount of such semi-annual in-

terest on the reclamation interest and sinking fund herein created. All sums derived from the interest on said bonds shall go into the general school fund for the support of the common schools of the State, and for the regular and prompt payment of which the faith and credit of the State is hereby pledged.

SEC. 24. There shall be levied and collected for the fiscal year commencing January first, A. D. eighteen hundred and ninety-one, and annually thereafter, an ad valorem tax of two cents on each one hundred dollars of all the taxable property in the State, and all sums derived from this tax shall go into the reclamation interest and sinking fund for the payment of the interest and redemption of bonds herein authorized by this act.

SEC. 25. The reclamation fund is hereby made a permanent fund, into which all revenue arising from the last-mentioned section, and from the water rent aforesaid, in section fifteen, and from any other source provided by law, shall be paid and shall be devoted as follows: First, to the payment of interest on bonds; second, to the redemption of the principal sum of the bonds at or before maturity; third, to the reclamation of new districts that may be hereafter created; fourth, to be transferred to the general fund of the State.

Approved March 3, 1889.

ARTESIAN WELLS.

SECTION 1. Section one of said act is hereby amended so as to read as follows:

Section one. Every person, firm, company, corporation, or association, that shall, after the passage of this act, commence the sinking of artesian wells, for stock or agricultural purposes, shall be entitled for sinking such artesian well, where flowing water is obtained, the following specified sums: For the first two hundred feet, one dollar and twenty-five cents per foot; for the third one hundred feet, one dollar and fifty cents per foot; for the fourth one hundred feet, two dollars per foot; for the fifth one hundred feet, two dollars and twenty-five cents per foot; for the sixth one hundred feet, two dollars and fifty cents per foot; for the seventh one hundred feet, three dollars per foot; for the eighth one hundred feet, three dollars and fifty cents per foot; for the ninth one hundred feet, four dollars per foot; for the tenth one hundred feet, four dollars and fifty cents per foot; for all depths exceeding one thousand feet, five dollars per foot for each and every foot below the said one thousand feet. And an additional bounty of one thousand dollars for every well sunk to the depth of one thousand feet or more: *Provided*, That such well shall furnish twenty thousand gallons of water each twenty-four hours, flowing continuously for thirty days, said sums to be paid in the manner provided for in sections four and five of this act: *Provided*, That no bounty shall be paid on any well which does not furnish seven thousand gallons of water in each twenty-four hours, flowing continuously for thirty days: *And provided further*, That no two wells shall receive a bounty if located within the same county. Where two or more wells within the prescribed limit apply for a bounty, the well which first furnished the amount of water required by this act shall be entitled to the bounty allowed by this act.

SEC. 2. Section six of said act is hereby amended so as to read as follows:

Section six. The sum of ten thousand dollars is hereby appropriated out of any money in the general fund of this State for the payment of bounties herein provided for.

OREGON IRRIGATION LAWS.

SEC. 4057. A right of way over any State lands belonging to the State of Oregon, school or University lands, tide or swamp, and overflowed lands, is hereby granted to any railroad corporation who may construct railroad over such lands, on each side of said road to the width of fifty feet.

SEC. 4058. A right of way for the construction of a water-ditch to be used for irrigation, manufacturing, or mining purposes, ditches or water-pipes for conveying water to cities and towns for domestic purposes or for the extinguishment of fires, is hereby granted to any individuals or corporations who may construct such water-ditches or water-pipes over any of the State lands belonging to the State of Oregon—tide, swamp, and overflowed lands, and school lands—for a distance on each side of said ditches or water-pipes of twenty-five feet.

SEC. 4059. It shall be the duty of said railroad corporation or water company or individuals constructing said railroads, water-ditches, or water-pipes to file a copy of the field-notes of the survey of such railroads, ditches, or water-pipes with the secretary of state of the State of Oregon, showing the location of said railroad, water-ditch, or water-pipe.

SEC. 4060. All patents hereafter granted by the State of Oregon for any of the class of lands heretofore mentioned shall be made subject to any vested rights of the owners of such railroads, water-ditches or water-pipes as may have been acquired under the preceding sections.

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NEW MEXICO IRRIGATION LAWS.

The treaty of peace between the United States and Mexico in 1848 contains the following provisions in Articles VIII and IX:

"ART. VIII. Mexicans now established in territories previously belonging to Mexico, and which remain for the future within the limits of the United States as defined by the present treaty, shall be free to continue where they now reside, or to remove at any time to the Mexican Republic, retaining the property which they possess in the said territories, or disposing thereof and removing the proceeds wherever they please, without being subjected on this account to any contribution, tax, or charge whatever.

"Those who shall prefer to remain in the said territories may either retain the title and rights of Mexican citizens, or acquire those of citizens of the United States; but they shall be under the obligations to make their election within one year from the date of the exchange of ratifications of this treaty, and those who shall remain in the said territories after the expiration of that year without having declared their intentions to retain the character of Mexicans shall be considered to have elected to become citizens of the United States. In the said territories property of every kind now belonging to Mexicans not established there shall be inviolably respected. The present owners, the heirs of these, and all Mexicans who may hereafter acquire said property by contract shall enjoy with respect to it guarantees equally ample as if the same belonged to citizens of the United States.

"ART. IX. Mexicans who in the territories aforesaid shall not preserve the character of citizens of the Mexican Republic conformably with what is stipulated in the preceding article shall be incorporated into the union of the United States and be admitted at the proper time (to be judged of by the Congress of the United States) to the enjoyment of all the rights of citizens of the United States according to the principles of the Constitution, and in the mean time shall be maintained and protected in the free enjoyment of their liberty and property, and secured in the free exercise of their religion, without restriction."

The Gadsden treaty between the United States and Mexico in 1853 contains the following provisions in Article V:

"All the provisions of the eighth and ninth, sixteenth and seventeenth articles of the treaty of Guadalupe Hidalgo shall apply to the territory ceded by the Mexican Republic in the first article of the present treaty, and to all the rights of persons and property, both civil and ecclesiastical, within the same, as fully and as effectually as if the said articles were herein again recited and set forth."

The Kearney code of laws, 1846, contains in section 1 the following provisions relative to water-courses, stock-marks, etc.:

"The laws heretofore in force concerning water-courses, stock-marks and brands, horses, inclosures, commons, and arbitration shall continue in force, except so much of said laws as require the ayuntamientos of the different villages to regulate these subjects. The duties and powers of such ayuntamientos are transferred to and enjoined upon alcaldes and prefects of the several countries."

IRRIGATION LAWS.

SECTION 1. No inhabitant shall have the right to construct any building to the impediment of the irrigation of lands or fields, such as mills or any other property, that may obstruct the course of the water, as the irrigation of the fields should be paramount to all other uses of the water.

SEC. 2. All by-paths or foot-paths are prohibited across the fields under penalty of fine or imprisonment.

SEC. 3. It being impracticable or absolutely impossible for the fields to be fenced in, all animals shall be kept under a shepherd, so that no injury may result to the fields, and in case any damage should result it shall be paid by the persons causing it.

SEC. 4. In case a community of people desire to construct a ditch or acequia, and the constructors are the owners of all the land upon which the ditch or acequia is constructed, no one shall be bound to pay for the land, as all persons interested in the construction are to be benefited by it.

SEC. 5. The course of ditches or acequias already established shall not be disturbed.

SEC. 6. All rivers and streams of water heretofore known as public ditches or acequias are hereby established and declared to be public ditches or acequias.

SEC. 7. From and after the publication of this act it shall be the duty of the several justices of the peace to call together in their respective precincts, whenever it may be deemed convenient, all the owners of ditches or acequias, as well as the proprietors of lands irrigated by any public ditch or acequia, for the purpose of electing one or more overseers for the ditches or acequias for the same year.

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SEC. 8. All fines and forfeitures recovered for the use and benefit of any public ditch or acequia shall be applied by the overseer to the improvements, excavation and to bridges for the same, wherever it is crossed by any public road and bridges may be necessary.

SEC. 9. In all cases of conviction under this act an appeal may be granted to the district court, which appeal shall be taken and conducted as all other appeals from the decisions of justices of the peace.

SEC. 10. The regulations of ditches or acequias which have been worked shall remain as they were made, and have remained up to this day.

SEC. 11. All plants of any description growing on the banks of the ditches or acequias shall belong to the owners of the land through which the ditches or acequias run.

SEC. 12. If any person or persons intentionally make lagoons of water, whether on their own or other land, after the gathering of the crops, from which lagoons damage results to houses, common or private grounds or public roads, the person so offending shall, on conviction, be fined in any sum not less than five nor more than ten dollars.

SEC. 13. Any person convicted of having committed injuries heretofore mentioned shall pay to the party injured the damages assessed by three persons appointed for that purpose by the justice.

SEC. 14. All fines arising from the provisions of this act shall be applied to the repairs herein mentioned, and in case of not being so expended, they shall go into the treasury of the county wherein they were collected.

SEC. 15. All acequias, public or private, when completed, shall be the property of the persons who may have completed them, and no person or persons who may desire the use of the waters of them shall be allowed to do so without the consent of a majority of the owners, and upon payment of a share proportionate to the primary cost of the acequia or ditch to the amount of the land proposed to be irrigated, or the quantity of water proposed to be used: *Provided*, That the provisions of this section shall not apply to any acequias or ditches, public or private, that may pass from the limits of any one county to within the lines of any other.

SEC. 16. Where any acequia or ditch, public or private, passes from within the limits of any one county to within the lines of any other, such acequia or ditch within the proper precincts of the respective counties shall be under the exclusive control and management of the officers of such precincts and counties.

SEC. 17. All the inhabitants shall have the right to construct either private or common acequias, and to take the water for them from wherever they can, with the distinct understanding to pay the owner through whose lands the acequias have to pass a just compensation for the land used.

SEC. 18. If the owner or owners of lands where a new ditch for an acequia is to be made should ask an exorbitant price as a compensation, which shall not be satisfactory to the owner or owners of the acequia, the probate judge of the county shall appoint three honest, skillful men to make an appraisement and fix the compensation, which once done shall be executed and without appeal.

SEC. 19. When any public ditch or part thereof shall be destroyed by rain, or in any other manner, and it shall be absolutely impossible to reconstruct it where it ran before it was destroyed, the major-domo of the ditch, with the consent, should they deem it necessary, of a majority of those having a common interest therein, may cut through the lands of any person or persons by first obtaining their consent, the community interested in the ditch offering to pay a compensation to be agreed upon between them and the owner or owners of the lands through which the ditch is to be opened.

SEC. 20. If the owner or owners who shall be solicited to permit the opening of a new ditch through their lands should refuse or decline to accept the compensation offered, or should ask a compensation which the interested parties consider exorbitant, the major-domo shall lay the case before the justice of the peace of the precinct, and he shall appoint three men, experts, to establish a just compensation to be paid to the owner or owners through whose lands the ditch is to pass.

SEC. 21. Whenever three experts shall be appointed as appraisers, they shall file in the office of the justice of the peace an oath impartially to discharge their duties, and shall proceed to the place where the land or lands are situated, and before appraising shall ascertain whether or not the ditch is destroyed, and whether the labor or cost required to rebuild it would be so great as to render its reconstruction impossible; and if they think the injury done may be repaired they will so report to the justice of the peace, and the land solicited for the purpose of opening the new ditch shall in no manner be touched; but if they should think a part of the ditch irreparably destroyed, they shall then examine the land or lands over which the new ditch should be opened and the place where it should properly run.

SEC. 22. Whenever any land or lands of any person or persons are appraised the appraisers shall file a report in the office of the justice of the peace who appointed

them, giving the name of the person whose land was appraised and the sum to be paid him by the parties interested in the public ditch for which the right of way through the land is solicited; they shall also state, in the most distinct manner, the place and point where the opening for the ditch is to be made, and the direction which the ditch is to take through such land.

SEC. 23. The parties interested shall possess the right of property in the land or lands assigned to them, and in case of legal resistance being made they may in an action of forcible entry and detainer, as provided by law, compel the person or persons who interpose such resistance to desist therefrom; but the parties interested shall first pay the appraised value of the land or lands: *Provided*, That the appraisers shall be impartial persons.

SEC. 24. In each precinct where public necessity requires it an election shall, on the third Monday of February, 1880, be held, as hereinafter provided, for directors of such of the acequias as irrigate different places.

SEC. 25. The manner of conducting the election, and the number of overseers, shall be regulated by the justice of the peace, and the only persons entitled to vote at the elections shall be the owners or renters of lands irrigated by the ditches or acequias.

SEC. 26. The overseers shall superintend the repairs and excavations on the ditches or acequias; apportion the number of laborers furnished by the proprietors; regulate them according to the quantity of land to be irrigated by each one; distribute and apportion the water in the proportion to which each one is entitled according to the land cultivated by him, taking into consideration the nature of the seed, crops, and plants cultivated.

SEC. 27. If any overseer of any public ditch or acequia shall willfully neglect or refuse to fulfill his duties, or conduct himself with impropriety or injustice, or take any bribe in money, property, or otherwise, he shall be fined for each of such offenses in a sum not exceeding $90, to be recovered before any justice of the peace in the county, one-half the sum to be paid to the county and the other half to the person bringing suit; and on a second conviction may be removed from his office on petition of two-thirds of the proprietors of the land irrigated.

SEC. 28. In all cases of removal the justice of the peace shall order a new election to fill the vacancy occasioned by it.

SEC. 29. The pay and other perquisites of the overseers shall be determined by a majority of the owners of the land irrigated by the ditch or acequia.

SEC. 30. In acequias of extended irrigation, and where the lands which they irrigate are unequal, and some persons have at once several sections and parts in other sections, there shall be elected a chief major-domo, an assistant major-domo, and three acequia commissioners. The duties of the commissioners shall be to regulate the number of laborers for the respective acequias for which they have been elected, that shall be furnished by each owner or tenant of irrigable lands to be irrigated. Should it be necessary, or should any three persons, owners, or tenants require it, the commissioners shall measure the lands in order to better apportion the number of laborers that each owner or tenant shall supply for the cleaning up of the acequias, and for any subsequent work which public necessity may demand during the year, the care of which is charged to the major-domos and assistant major-domos, the chief major-domo being always the superior officer; and he, with his assistant, shall take care that the acequias shall be kept running in all their vigor from the time the water is first let in after cleaning until the crops no longer require it.

SEC. 31. Whenever a list has been made by the acequia commissioners, as provided in the foregoing section, at any of the acequias, or by any major-domo and his assistant, where commissioners are not elected, another list shall be made and delivered to the justice of the peace, who shall record it for the reference of all interested parties and in order that the work may be so ordered.

SEC. 32. The chief majors-domo of all the acequias shall be the receivers and disbursers of all the fines resulting from their respective acequias, and on the tenth of October in each year they shall give an account to the justices of the peace of their precincts of the fines received and the manner in which they have disbursed any part of them.

SEC. 33. Should the commissioners be charged with the duty of measuring the lands, they shall be paid at the rate of two dollars per diem during the time they may be so occupied, which sum shall be paid from the respective funds belonging to the acequias.

SEC. 34. In the elections every owner or tenant of irrigable lands irrigated by any of the acequias shall be entitled to vote and be voted for. The persons receiving the greatest number of votes shall be declared elected to their respective offices, and shall receive a certificate of the same from their respective justices of the peace. All such elections shall be held from and after the year eighteen hundred and eighty-one, on the first Monday of January in each year.

SEC. 35. All persons interested in a common ditch or acequia, be they owners or lessees, shall labor thereon in proportion to their land,

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SEC. 36. All owners of tillable lands shall labor on public ditches or acequias, whether they cultivate the land or not.

SEC. 37. Each proprietor shall furnish the number of laborers required by the overseer, at the time and place he may designate and for the time he may deem necessary.

SEC. 38. If a proprietor of land irrigated by any such ditch or acequia shall neglect or refuse to furnish the number of laborers required by the overseer after having been legally notified, he shall be fined for each offense in a sum not exceeding ten dollars for the benefit of the ditch or acequia, and the overseer shall be a competent witness to prove the offense.

SEC. 39. If any person shall in any manner obstruct, interfere with, or disturb any of the ditches or acequias, or use the water therefrom without the consent of the overseer during the time of cultivation, he shall pay for each offense a sum not exceeding ten dollars and all damages that may have accrued to the injured parties, and if the person or persons are unable to pay the fine and damages they shall be sentenced to fifteen days' labor on public works.

SEC. 40. All overseers of ditches shall see that the water currents run so that no injury may result to the proprietors of lands or tenements or to the public convenience; and in case danger is anywhere threatened by the ditches, either from increase of water or by inundation, from which damage might result, the overseers are required, if the damage might result to but one precinct, to report the danger to the justice of the peace, and if to two or more, to the probate judge of the county.

SEC. 41. The probate judge, or the justice of the peace, shall appoint three suitable persons to make an examination, and if they shall sustain the report made by the overseer the probate judge or the justice of the peace shall order all persons owning real estate within the limits considered in danger to meet together, and, under direction of the overseer or some other person appointed, set about the prevention of damages by the construction of breakwaters, barriers, or any other work deemed advisable as a means of averting the threatened injury: *Provided*, That the labor shall be performed in proportion to the property of each person interested in the same.

SEC. 42. In all cases where it becomes necessary to take any of the steps mentioned, the person in charge shall direct the labor, notify the parties interested of the number of laborers to be furnished and the part of the work assigned to such parties respectively, and informing them of the place where work shall commence and the day appointed for commencing it: *Provided*, That if after receiving the notice any person or persons shall fail to comply, the person in charge may report to the judge or justice by whom he was appointed who shall cause the delinquent to appear, and fine him in any sum not less than five dollars.

SEC. 43. Every person being a tiller of irrigated lands, who shall have commenced the performance of his part in the common labor on any public acequia, is and shall be obligated to continue on that work until the completion of the cleansing of the acequia.

SEC. 44. If any owners or lessees of lands shall attempt to abandon their co-laborers without complying with sections forty-five and forty-six, they shall each pay a fine of not less than five dollars, nor more than ten dollars.

SEC. 45. If any person having his fields on the upper portion of an acequia, having reached such fields, shall propose for any cause or causes, reason or pretext, to abandon his co-laborers, or to withdraw his quota of laborers, he shall not be permitted so to do until the completion of the cleansing of the acequia: *Provided*, That touching the repairs and excavations to be made, the proper proportion of labor shall be furnished by the owners, and the majors-domo shall superintend the work as heretofore provided. If in any acequias already constructed there shall be included any dikes and dams which may have been destroyed, and the parties interested in such dikes and dams shall have agreed or contracted to work on the acequia, they shall remain and fulfill their engagements.

SEC. 46. As in the excavation of such acequias, and in the first cleansing of some of them, the work sometimes continues for thirty days, more or less, the different majors-domo shall take into consideration the small amount of land tilled by some, and shall not compel these to furnish as much labor as is required of those having larger interests.

SEC. 47. Every owner or tenant of irrigable lands, irrigated by any of the acequias, shall be compelled to hold at all times during the operations of any acequia to which they belong, the number of laborers to them assigned, at the disposal and order of the major-domo of such acequia, or his assistant, and it shall not be legal for any owner or tenant of irrigable lands, to absent himself for a time exceeding three days without informing the chief major-domo in regard to the persons remaining in his stead, and he shall present them, so that in his presence they may assume the responsibilities during the time of his absence. All the responsibilities of the absentees shall fall on the substitutes, and no other persons shall be admitted as substitutes. And if any owner or tenant of irrigable lands shall absent himself from the precinct during the

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time the acequias are in operation, without complying with the duty imposed upon him, he shall besides paying the penalty fixed by the major-domo, be responsible for an amount equal to the value of the labor due at a just and common estimate per diem for the time he was absent and for the number of laborers that may have been assigned to him. Nor shall any proprietor, on account of having rented his lands reserving a part for himself, be exempted from working on the acequia at any time of the work.

SEC. 48. This section relates to the penalties for failure to perform work due on an acequia, the disbursement of the sums collected as fines, etc.

SEC. 49. All currents and sources of water, such as springs, rivers, ditches flowing from natural sources, shall be and they are by this act declared free, in order that all persons traveling shall have the right to take water therefrom for their own use and that of the animals under their charge; but the word traveler shall not in any manner extend to persons who travel with a large number of animals; such persons shall not use the water of any spring belonging to any individual, without having first obtained the consent of the owner. And if any person in transit or traveling, at the time of using any of the water mentioned, shall cause any injury to the fields, to lands under crop, or to other property of any person, he shall pay to the injured party all damages that may have been done: *Provided, further*, That this act shall in no manner apply to wells: *Provided, further*, That this act shall not be applicable to ponds or reservoirs of water that persons may construct for their own proper use and benefit, and no person under pretext of title to the sources, springs, rivers, or ditches, shall have the right to embarrass or hinder, or molest any transient person or traveler in or at the time of taking the water for his proper use and giving water to his animals.

SEC. 50. Hereafter, if any person or persons shall embarrass, hinder, and molest any person or persons at the time they may wish to take water for their animals, and shall claim or demand any compensation for the use of the same, the person or persons so offending shall be fined not less than twenty-five dollars, nor more than fifty dollars, and shall be liable to pay all the damages caused to the person hindered.

SEC. 51. Every person who shall foul the water of any stream, or throw into any ditch, river, or spring of flowing water any dead or pestiferous animal or other filth, dirty vessels, or other impurities that might injure the general health of the inhabitants of any town or settlement, shall be fined not less than one dollar nor more than ten dollars.

SEC. 52. The major-domos of the ditches, and the commissioners of the same, shall prosecute all persons violating the provisions of this act.

SEC. 53. All the salt lakes, with the salt which has accumulated or may accumulate on their shores, are and shall be free to the citizens; and each one shall have power to collect salt on any occasion free from molestation or disturbance. If any person or persons shall prevent, or attempt to prevent, any other person or persons from gathering salt, or going for or returning with it, or if any persons shall arm or embody themselves for any or either of the above purposes, or shall molest, disturb hinder, or annoy any person or persons while gathering salt, or going to or returning from any salt lake, or shall interfere with the salt gathered, or the animals, carts, or wagons, or any other convenience used in its carriage, shall be guilty of felony, and shall be punished by confinement in the county jail or Territorial prison not less than two nor more than seven years, nor be fined not less than one thousand dollars.

SEC. 1305. The different communities or Pueblos of Indians residing within our settlements shall be subject to render their services in working the acequias and highways in which they have the common use of the water of said acequias with the immediate citizens to their Pueblos, and enjoy at the same time the benefit and commercial traffic: *Provided*, That in such service they shall be entirely subject to the laws now in force on both branches of roads and acequias.

In addition to the foregoing there prevails among the Pueblo Indians of New Mexico the custom of annually electing a major-domo by all interested. He has control over the distribution of the water and calls out the help required for repairs, etc., much in the same manner as practiced among the Mexicans.

TEXAS IRRIGATION LAW.

CHAP. 88.—[S. H. B. No. 298.] An act to encourage irrigation, and to provide for the acquisition of the right to the use of water, and for the construction and maintenance of canals, ditches, flumes, reservoirs, and wells for irrigation, and for mining, milling, and stockraising in the arid districts of Texas.

SECTION 1. That the unappropriated waters of every river or natural stream within the arid portions of the State of Texas, in which, by reason of the insufficient rainfall, irrigation is necessary for agricultural purposes, may be diverted from its natural channel for irrigation, domestic, and other beneficial uses: *Provided*, That said water shall not be diverted so as to deprive any person who claims, owns, or holds a posses-

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sory right or title to any land lying along the bank or margin of any river or natural stream of the use of the water thereof for his own domestic use.

SEC. 2. That the unappropriated waters of every river or natural stream within the arid portions of the State, as described in the preceding section of this act, are hereby declared to be the property of the public, and may be acquired by appropriation for the uses and purposes as hereinafter provided.

SEC. 3. The appropriation must be for the purpose named in this act, and when the appropriator, or his successor in interest, ceases to use it for such purposes the right ceases.

SEC. 4. As between appropriators, the one first in time is the one first in right to such quantity of the water only as is reasonably sufficient and necessary to irrigate the land susceptible of irrigation on either side of ditch or canal.

SEC. 5. Every person, corporation, or association of persons which have constructed or may hereafter construct any ditch, canal, or reservoir, for the purposes named in this act, and taking water from any natural stream, shall, within ninety days after this act goes into effect, or within ninety days after the commencement of such construction, file and cause to be recorded in the office of the county clerk of the county where the head gate of such ditch or canal may be situated, or to which said county may be attached for judicial purposes, in a well-bound book to be kept by said clerk for that purpose, a sworn statement in writing, showing the name of such ditch or canal, the point at which the head gate thereof is situated, the size of the ditch or canal in width and depth, and the carrying capacity thereof in cubic feet per second of time, the name of said stream from which said water is taken, the time when the work was commenced, and the name of the owners or owner thereof, together with a map showing the route of said ditch or canal.

SEC. 6. Within ninety days next after the filing of said statement, the party claiming the right to appropriate the water shall begin the actual construction of the proposed ditch, canal, or reservoir, and shall prosecute the work thereon diligently and continuously to completion.

SEC. 7. "Completion," as used in the preceding section, is hereby defined to be the conducting of the water in the main canal to the place of intended use.

SEC. 8. By compliance with the preceding provisions of this act the claimant's right to the use of the water relates back to the time when the work of excavation or construction was commenced on said proposed ditch, canal, or reservoir: *Provided*, That a failure to file said statement shall in no wise work a forfeiture of such heretofore acquired rights, nor prevent such claimants of such heretofore acquired rights from establishing such rights in the courts.

SEC. 9. When any person, corporation, or association of persons, by compliance with the preceding provisions of this act, shall become entitled to the use of the waters in any river or stream, it shall thereafter be unlawful for any other person, corporation, or association of persons, except for domestic use by any one entitled thereto, to so divert the flow of water in said river or stream in such manner and to the extent of depriving said person, corporation, or association of persons in priority of the use of the water to which they may be so entitled.

SEC. 10. Corporations may be formed and chartered under the provisions of this act and of the general incorporation laws of the State of Texas, for the purpose of constructing, maintaining, and operating canals, ditches, flumes, feeders, laterals, reservoirs, and wells, and of conducting, transferring, and furnishing water to all persons entitled to the same, for irrigation and domestic uses, and for the purpose of building storage reservoirs for the collection and storage of water for the uses before mentioned, and for mining, milling, and stock-raising. All persons who own or hold a possessory right or title to land adjoining or contiguous to any canal, ditch, flume, or lateral, constructed and maintained under the provisions of this act, and who shall have secured a right to the use of water in said canal, ditch, flume, or lateral, shall be entitled to be supplied from such canal, ditch, flume, or lateral with water for irrigation of such land and domestic uses: *Provided*, The party so entitled shall first make available his said land for agricultural or grazing purposes, and shall provide cisterns, wells, or storage reservoirs for water for domestic purposes.

SEC. 11. All corporations and associations formed for the purposes of irrigation as provided in this act, are hereby granted the right of way, not to exceed one hundred feet in width, over all public, university, school, and asylum lands of the State, with the use of the rock, gravel, and timber on the right of way, for construction purposes, and may obtain the right of way over private lands by contract. Any such corporation may also obtain the right of way over private lands by condemnation by causing the damages for any private property appropriated by such corporations or associations to be assessed and paid for as provided in cases of railroads.

SEC. 12. All surplus water not used or disposed of, as provided for in the preceding sections of this act, shall be conducted back to the stream from which it was taken. And all water sold or disposed of may be measured in inches, feet, or fractional portion of the whole supply, or distributed by the hour or acre system. But

any person, corporation, or association of persons shall furnish water in the way and manner named in the contract or certificate issued to the purchasers of said water, so long as water remains unsold in the ditch: *Provided*, That the commissioner of agriculture, insurance, statistics, and history shall make a report to the legislature at its next regular session, and at each regular session thereafter, as to the cost and expense attending the construction and maintenance of canals, ditches, flumes, feeders, and wells for irrigation in various parts of the State, and accompany the same with a statement of the charges made for the uses of water by canal, ditch, and well companies, and the legislature shall, at such times as it deems proper, either by direct legislation or by the creation of a commissioner or water inspector or inspectors, with full delegated power, control and regulate the quantity of water which may be diverted by any water company or individual, when and in the manner in which it may be diverted, and may establish and enforce all such reasonable rules and regulations necessary and proper governing and controlling such corporations and water construction companies and persons operating under the provisions of this act, and may also control, regulate, change, and fix the charges for the use of water made by such ditch, canal, and well companies.

SEC. 13. All said persons, corporations, and associations shall have the right to run along or across all roads and highways necessary in the construction of their work, and shall at all such crossings construct and maintain necessary bridges for the accommodation of the public, and shall not affect or impair the usefulness or condition of said road or highway.

SEC. 14. Any person who shall willfully or through gross negligence injure any irrigating canal or its appurtenances, wells, or reservoirs, or who shall waste the water thereof, or shall take the water therefrom without authority shall be deemed guilty of a misdemeanor, and for each offense shall be liable to a fine not exceeding five hundred dollars.

SEC. 15. Any corporation created and organized under the provisions of the general laws of this State or the provisions of this act for the purpose of irrigation shall have the power to acquire lands by voluntary donation or purchase or in payment of stock or water rights, and to hold and dispose of all such lands and other property, and to borrow money for the construction, maintenance, and operation of its canals, ditches, flumes, feeders, reservoirs, and wells, and may issue bonds and mortgage its corporate property and franchises to secure the payment of any debt contracted for the same: *Provided*, All lands acquired by said corporation, except such as are used for the construction, maintenance, and operation of said canals, ditches, laterals, feeders, reservoirs, and wells shall be alienated within twenty years from the date of acquiring said lands or be subject to judicial forfeiture.

SEC. 16. All laws and parts of laws in conflict with the provisions of this act are hereby repealed.

SEC. 17. Whereas it is necessary that irrigating canals should be built at once to afford water for irrigational purposes for the present year; therefore an emergency exists, and an imperative public necessity demands the suspension of the constitutional rule which requires a bill to be read on three several days, and that this act take effect and be in force from and after its passage.

CHAPTER REGULATING THE MODE OF IRRIGATION.

ART. 2982. The commissioners' court are authorized to order, regulate, and control the time, mode, and manner of erecting, repairing, cleaning, guarding, and protecting the dams, ditches, roads, and bridges belonging to any irrigation farms and property and the fences or other like protection in and around such farms: *Provided*, That such farms, dams, ditches, and fences be owned conjointly by two or more different persons: *And provided further*, That the same be situated outside of a corporation having jurisdiction thereof.

ART. 2983. Said courts shall have power to establish all needful police regulations for the government and control of irrigation farms and property, and said courts may assess and collect fines for breaches of any regulations established by them or by the joint owners of such farms and property, or recognized by said court as consistent with ancient usage and the law of the State; said courts may order meetings of joint owners for the election of commissioners and other officers, and for the consideration of any of their other interests, or the said court may proceed and elect said officers, and may regulate the right of way, the stoppage and passage of the water, and the right distribution of the shares of said water; they may forbid the running of stock at large on the common farm; they may fine for taking water out of turn and for carelessness and wantonness in overflowing roads and neighboring lands, and generally they may do or cause to be done what they consider just and needful or beneficial to the jointowners.

ART. 2984. If any owner of a *suerte* or subdivision lot in said farm shall fail or refuse to do or pay his proportion of labor and expense in and on any dam, ditches, fences,

bridges, or other needful appurtenances to such irrigation farms, the commissioners' court may lease said *suerte: Provided*, That such leasing shall be at public outcry, after ten or more days of due public notice; and to the person bidding the shortest term, not to exceed four years, who shall give good security to discharge faithfully all such charge and work.

ART. 2985. Upon the application of the owners of any suitable lands and water and the assurance and the proper security given the county, if required by said court, that no injury will result to the public health, the commissioners' courts are authorized by decree to license and permit any such owners to proceed and dam the water and to ditch, fence, and irrigate their lands: *Provided*, That joint owners of all irrigation farms shall be liable for damages done to the public or to any person by reason of the overflow of such irrigation water; suit to be brought against the person occasioning the injury or in such other way as may be sanctioned by said court.

ART. 2986. If, in the establishment of any new project of irrigation or the extension thereof, the commissioners' court deem it of sufficient importance to order a dam or ditch to be made on the lands of any person refusing to consent thereto, the said court, after giving such person actual notice in writing and full hearing and consideration of his objections, may decree the making of the same and shall depute two or more discreet and disinterested freeholders of the vicinage to arbitrate and fix the amount of damage permanently sustained by such person, which shall, by that or another such commission, be levied upon and paid forthwith by the applicants for such irrigation project in the ratio of the interest and several shares of the said applicants and joint owners, and the said courts may, after like personal notice to parties interested, order the multiplication or extension of any ditches for irrigation, and of irrigation, and of irrigation farms at and below, or at the sides of other such property, when it shall be the duty of such court to proceed and assess all just fines and equitable damages, and to fix and direct the rate and amount and kind of work, labor, and tax to be paid by any of such applicants and others, according to their interest.

ART. 2987. Where the health of the public may be injured by irrigation or the damming up of water for any purpose it shall be the duty of the commissioners' courts, after due mature hearing and consideration, to decree the discontinuance, and they shall proceed and break up and discontinue all such dams, ditches, and irrigation, whether the same have been heretofore ever so long in existence or may hereafter be started.

ART. 2996. All corporations for irrigation or navigation are hereby granted the right of way, not to exceed one hundred feet in width, over all public, university, school, and asylum lands, with use of necessary rock, gravel, and timber for construction purposes, and may attain the right of way over private lands by contract, or the damages for any private appropriated by such corporations shall be assessed and paid for as provided for in cases of railroads.

ART. 3000. Whenever any canal or ditch for irrigation shall be constructed under the provisions of this chapter, all persons owning lands adjacent to and irrigable from said canal or ditch, shall have the right to use the water of said canal or ditch, under such regulations as may be prescribed by law or by the commissioners' court of the county where such lands are situated.

UTAH IRRIGATION LAWS.

WATER RIGHTS.

SEC. 422. Whenever, by priority of possession, rights to the use of water for mining, agriculture, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws, and the decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed; but whenever any person, in the construction of any ditch or canal, injures or damages the possession of any settler on the public domain, the party committing such injury or damage shall be liable to the party injured for such injury or damage.

SEC. 423. All patents granted, or pre-emption or homesteads allowed, shall be subject to any vested and accrued water right, or rights to ditches and reservoirs used in connection with such water rights, as may have been acquired under or recognized by the preceding section.

SEC. 424. The right to the use of water for the reclamation of desert lands, in accordance with the provisions of an act approved March third, eighteen hundred and seventy-seven, shall depend upon bona fide prior appropriation; and such right shall not exceed the amount of water actually appropriated, and necessarily used for the purpose of irrigation and reclamation; and all surplus water over and above such actual appropriation and use, together with the water of lakes, rivers, and other

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sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes, subject to existing rights.

SEC. 425. All navigable rivers, within the Territory occupied by the public lands, shall remain and be deemed public highways; and in all cases where the opposite banks of any streams not navigable belong to different persons, the stream and the bed thereof shall become common to both.

SEC. 2775. s 1. The selectmen of the several counties of this Territory are hereby created ex officio water commissioners for their respective counties, whose powers and duties shall be to make, or cause to be made and recorded, such observations, from time to time, as they may deem necessary, of the quantity and flow of water in the natural sources of supply, and to determine, as near as may be, the average flow thereof at any season of the year, and to receive, hear, and determine all claims to the use of water, and on the receipt of satisfactory proof of any right to the use of water having vested, to issue to the person owning such right a certificate therefor for recording, and to generally oversee, in person, or by agents appointed by them, the distribution of water within their respective counties, from natural sources of supply, to all the corporations or persons having joint rights in and to any natural source of supply, and to fairly distribute, according to the nature and extent of recorded rights, and according to law, to each of said corporations or persons their several portions of such water; and in case of dispute between any of such persons or corporations as to the nature or extent of their rights to the use of water or right of way, or damages therefor, of any one or more of such persons or corporations, to hear and decide upon all such disputed rights, and to file a copy of their findings and decisions as to such rights with the county recorder, and to distribute the water according to such findings or decision, unless otherwise ordered by a court of competent jurisdiction.

SEC. 2776. s 2. In cases where persons, or corporations, use water in different counties from the same natural source of supply, the water commissioners of each of said counties shall unite in appointing, either from among their number or otherwise, as they may determine, a board of reference of not less than three competent persons, to hear and decide all disputes in regard to water rights in and to such natural source of supply, and they shall file a copy of their decision with the county recorders of each of said counties; said water commissioners and members of the board of reference shall each, respectively, have power to administer oaths, and if any person who may be duly sworn in any matter in relation to the nature, extent, or exercise of any right or duty under any of the provisions of this act, shall falsely swear, such person shall be deemed guilty of perjury.

SEC. 2777. s 3. The certificate of the water commissioners shall state generally the nature and extent of the right to use water of the person, or corporation, to whom it is issued, and must be filed with the county recorder for recording.

SEC. 2778. s 4. It shall be the duty of the county recorder of each county, upon any certificate of water commissioners being filed in his office, as prescribed by this act, and upon any findings or decisions of any commissioners, or board of reference, as to the extent of any such rights, and upon payment of the fees allowed by law for such service, to record, in a book, or books, to be kept by him for such purposes, all such certificates, findings, and decisions, which said record shall be deemed to impart notice to all persons whomsoever of the contents thereof, and shall be prima facie evidence of the existence and verity of the facts therein recited.

SEC. 2779. s 5. No person, or corporation, shall maintain any suit, at law or in equity, for the determination of the existence or extent of any right, or rights, to the use of water in this Territory, until after the decision of the proper county commissioners, or of the proper board of reference, as the case may be, unless said commissioners, or board, shall fail and neglect to hear and decide such person's claim of right to use of water for more than three months after such person may have presented, in writing, his claim, or claims, and evidence in support thereof, for adjudication: *Provided*, This section shall not be construed to affect or impair the authority or jurisdiction of any court in the issuance of a temporary injunction or restraining order in such cases, or to abridge the right of any person aggrieved by any such decision to maintain any lawful suit, or appeal, after such decision may have been made.

SEC. 3780. s 6. A right to the use of water for any useful purposes, such as for domestic purposes, irrigating lands, propelling machinery, washing and sluicing ores, and other like purposes, is hereby recognized and acknowledged to have vested and accrued, as a primary right, to the extent of, and reasonable necessity for such use thereof, under any of the following circumstances:

1. Whenever any person or persons shall have taken, diverted, and used any of the unappropriated water of any natural stream, water-course, lake, or spring, or other natural source of supply.

2. Whenever any person or persons shall have had the open, peaceable, uninterrupted, and continuous use of water for a period of seven years.

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SEC. 2781. s 7. A secondary right to the use of water for any of said purposes is hereby recognized and acknowledged to have vested and accrued (subject to the perfect and complete use of all preliminary rights) to the extent of and reasonable necessity for such use thereof, under any of the following circumstances:

1. Whenever the whole of the waters of any natural stream, water-course, lake, spring, or other natural source of supply has been taken, diverted, and used by prior appropriators for a part, or parts, of each year only; and other persons have subsequently appropriated any part, or the whole, of such water during any other part of such year, such person shall be deemed to have a secondary right.

2. Whenever, at the time of an unusual increase of water exceeding seven years average flow of such water, at the same season of each year, all the water of such average flow then being used by prior appropriators, and other persons appropriate and use such increase of water, such persons shall be deemed to have acquired a secondary right.

SEC. 2782. s 8. A right to the use of water may be measured by fractional parts of the whole source of supply, or by such fractional parts, with a limitation as to periods of time when used, or intended to be used; or it may be measured by cubic inches with a limitation as to periods of time when used or intended to be used; or it may be measured by cubic inches with a limitation specifying the depth, width, and declination of the water at point of measurement, and, if necessary, with a further limitation as to periods of time when used, or intended to be used, and such right may be appurtenant to the land upon which such water is used, or it may be personal property, at the option of the rightful owner of such right, and a change of the place of use of water shall in no manner affect the validity of any person's right to use water, but no person shall change the place of use of water, to the damage of his coowners in such right, without just compensation.

SEC. 2783. s 9. A continuous neglect to keep in repair any means of diverting or conveying water, or a continuous failure to use any right to water, for a period of seven years at any time after the passage of this act, shall be held to be abandonment and forfeiture of such right, and whenever hereafter a conveyance of any parcel of land is executed, and a right to the use of water has been continuously exercised from the time of its first appropriation, in irrigating such land, such right shall pass to the grantee of such conveyance; and in cases where such right has been exercised in irrigating different parcels of land at different times, such right shall pass to the grantee of any parcel of land on which such right was exercised next preceding the time of the execution of any conveyance thereof; subject, however, in all cases to payment by the grantee of any such conveyance, of all amounts unpaid on any assessment then due upon any such right: *Provided*, That in any of the cases mentioned in this section, any such right to the use of water, or any part thereof, may be reserved by the grantor of any such conveyance, by making such reservation in express terms inserted in such conveyance.

SEC. 2784. s 10. All rights to the use of water, and means of diverting water, shall be exempt from taxation, except for the purpose of regulating the use of the exercise of such right in all cases where the land or other property upon which the pertaining to such rights is assessable for taxation, but in making the assessment the assessor shall estimate the increased value of such land or other property, caused by the use of such water.

SEC. 2785. s 11. It shall be the duty of all persons using water from any natural source of supply to provide suitable ditches for conveying surplus water again into the natural channel, or other places of use, to the satisfaction or approval of the water commissioners; and if, through neglect so to provide such ditches, water is allowed to form pools or marshes, or otherwise run to waste, and if any person shall turn or use any water in a manner that damages the property of another, except when such turning or using in the prudent, careful exercise of such person's lawful right to so turn or use, such person or persons so offending shall be liable for damages to any aggrieved person entitled to the use of water from the same source of supply, and the water commissioners may, on application, or of their own motion, cause the water supply to be diverted from such offending party until such waste ditches are provided.

SEC. 2786. s 12. Whenever the terms mentioned in this section are employed in this act, they are employed in the sense hereinafter affixed to them, except when a different sense plainly appears:

1. The term "person," when applicable, includes "firm," "partnership," "joint stock company," "association," and "corporation."

2. Words in the singular number may include the plural, and words in the masculine may include the feminine.

3. The term "continuous use" includes use for that part of each year necessary for the purpose used for.

SEC. 2787. s 14. Whenever the waters of any natural source of supply are not sufficient for the service of all those having primary rights to the use of the same, such water shall be distributed to each owner of such right in proportion to its extent, but

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those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for irrigating lands shall have preference over those using the same for any other purpose, except domestic purposes: *Provided*, Such preference shall not be exercised to the injury of any vested right, without just compensation for such injury.

SEC. 2788. s 15. All persons shall have the right of way across and upon public, private, and corporate lands, or other right of way, for the construction and repair of all necessary reservoirs, dams, water-gates, canals, ditches, or flumes, other means of securing and conveying water for any necessary public use, or for drainage, upon payment of just compensation therefor, but such right of way shall in all cases be exercised in a manner not to unnecessarily impair the practical use of any other right of way, highway, or public or private road, nor to unnecessarily injure any public or private property.

SEC. 2789. s 16. Whenever a majority of individuals owning several rights to the use of water, and a joint interest in the means of diverting or conveying such water, or who may desire to divert and use any unappropriated water, desire to organize themselves into an association for the purposes of regulating the diversion and distribution of such water, they may organize into a corporation in the manner provided in "An act providing for incorporating associations for mining, manufacturing, commercial, and other industrial pursuits," approved February 18, 1870, and all amendments thereto, with power to levy and collect all necessary assessments, and the distribution of water to each stockholder may be regarded as the payment of dividends, and such corporation shall have perpetual succession, unless dissolved by three years' non-use of its rights, or by a two-thirds majority vote of its members, at a meeting called for that purpose; in all cases of dissolution, the property held by the corporation shall revert to the members in proportion to their rights therein, or they may organize into an irrigation district, under "An act to incorporate irrigation companies," approved January 20, 1856, as they may elect.

AN ACT COMPILING THE LAWS RELATING TO THE INCORPORATION OF IRRIGATION COMPANIES.

SEC. 2403. s 1. *Be it enacted, etc.*, That upon the majority of the citizens of any county or part thereof, representing to the county court that more water is necessary, and that there are streams or parts of streams unclaimed or unused, which, if brought out of their natural channels and thrown upon tracts of land under cultivation, or to be put under cultivation, can be of value to the interests of agriculture, the county court having jurisdiction may proceed to organize the county, or part thereof, into an irrigation district; and thereafter the land-holders of such district shall be equally entitled to the use of the water in or to be brought into such district, according to their acknowledged rights: *Provided*, Such land-holders pay their proportion of the expense incurred in the construction and keeping in repair of the necessary canals, flumes, dams, or ditches

SEC. 2404. s 2. The citizens of an irrigation district, when so organized for the purposes provided in the preceding section, may, in mass-meeting, proceed to the formation of a company, by electing, *viva voce*, not less than three nor more than thirteen trustees, a secretary, and a treasurer. Notice of the time, place, and object of said mass-meeting shall be given by the clerk of the county court at least ten days previous by advertising three times in some newspaper having general circulation in the county, and by posting up notices in three public places in the district.

SEC. 2405. s 3. It shall be the duty of the trustees so elected to locate the proposed canal or ditch, determine the amount and quality of the land to be benefited thereby, to estimate the cost, including dams, flumes, locks, waste-weirs, and all the appurtenances belonging thereto, the amount per acre of the percentage on taxable property which will be necessary to construct the same.

SEC. 2406. s 4. It shall then be the duty of the trustees to make a report to the county court of the location and estimate provided for in section 3 of this act; also to call a meeting of the holders of the lands to be benefited by the proposed canal or ditch, at which a copy of said report shall be presented, and the said land-holders shall vote "yes" or "no" upon the following questions:

1. Do you mutually agree to pay —— per acre, land tax, to construct the proposed canal or ditch?

2. Do you approve the action of the mass-meeting in the election of officers?

Notice shall be given by the trustees at least ten days previous to the time appointed for such meeting, by advertising at least three times in some newspaper having general circulation in the county, and by posting up notices in three public places in the district. Said advertisement and notice shall state distinctly the time and place and object of such meeting, and be signed by a majority of the trustees and the secretary. The voting at said meeting shall be by ballot, and the chairman and secretary of said meeting shall be the judge and clerk of the election. A ballot-box shall

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be provided by the trustees, and each voter shall present his ballot to the judge of election, who shall deposit it in the box, and the clerk shall write the name of the voter in a poll-list or book, which shall also be provided by the trustees. No person shall be entitled to vote at said meeting or election unless he is a land-holder in the district. Immediately after the close of the election the ballots shall be openly counted by the judge and clerk, assisted by two persons chosen by the voters present. A certificate of the results of the election, signed by the persons who counted the votes, shall be forwarded at once to the clerk of the county court by the judge of said election.

SEC. 2407. s 5. If upon counting the votes it shall appear that two-thirds of the votes polled have been answered in the affirmative, then the tax so agreed upon shall be a law in the said irrigation district; and the tax when collected shall be paid over to the treasurer of said company on his order: *Provided*, That not exceeding one-half of the tax so agreed upon shall be collected at one time, and the residue to be collected as the work progresses: *Provided further*, That if the first estimate prove insufficient for the construction of the canal or ditch with its appurtenances, then additional taxes may be assessed in the same manner as hereinbefore provided until the said canal or ditch is completed.

SEC. 2408. s 6. If less than two-thirds of the votes polled are answered in the affirmative, then all proceedings under this act shall be null and of no effect: *Provided*, That if there are objections to the officers so elected by the mass-meetings, the electors may write other names on their tickets; the persons having the most votes to be declared elected, and it shall be the duty of the county clerk to notify such officers forthwith of their election.

SEC. 2409. s 7. Within twenty days after receiving such notice, the officers so elected shall file bonds in the office of the clerk of the county court, conditioned for the faithful performance of their several duties; the amount of such bonds to be declared by the county court having jurisdiction.

SEC. 2410. s 8. The term of office of the first trustees, secretary, and treasurer shall be till the next general election, and thereafter for two years, and until their successors are elected and file bonds.

SEC. 2411. s 9. All subsequent elections for determining the rate of tax shall be held annually on the first Monday in December, and for the election of company officers, biennially, on the same day, at such time and place within the district as shall be designated by the trustees, at which time the number of trustees may be changed by a two-thirds vote to not less than three nor more than thirteen. Notice of said election shall be given and the election conducted and certificates thereof returned, as provided in section 4 of this act, and the officers elected shall give bonds as provided in section 7 of this act. The rate of tax determined at said election by a majority vote shall be a law in said irrigation district, and shall constitute a permanent lien on the interest of the tax-payer in said canal or ditch and his right to the use of the water therein flowing from the day of assessment: *Provided*, That no tax created or payable by this act shall be or create a lien upon the land.

SEC. 2412. s 10. The trustees at their first meeting shall elect one of their number president, and it shall be their duty and they shall have power to fill any vacancy which may occur in the board by death, change of residence, or otherwise; and the persons chosen for this purpose shall hold office until the next annual election. The trustees shall also have power to meet at such times and places as they may deem expedient to make by-laws, rules, and regulations necessary to carry into effect the objects of the people; to appoint agents, subordinates, and officers, and employ such workmen as may be requisite; to appoint assessors and collectors, or make agreement with the county assessors to assess and collect the tax, and notify collectors when additional installments of the tax will be needed; to construct and complete said canals or ditches, with all necessary appurtenances thereto; to cause to be kept an account of all receipts and disbursements, and to complete said canals and ditches, and settle all accounts of the same. Said trustees shall make an annual report of their proceedings under this act to the county court on or before the first day of February, and shall file with the clerk of the county court a map of said irrigation district, showing the location and subdivision of land therein, and of the company's canals and ditches.

SEC. 2413. s 11. The trustees shall have power to sue and be sued, plead and be impleaded, to have and to hold all such real estate and personal property as may be necessary to construct the contemplated ditch or canal, including all appurtenances belonging thereto.

SEC. 2414. s 12. If any part of the lands to be benefited by the proposed ditch or canal are not legally claimed, then such lands may be appraised by the trustees and shall be held and the possession of them sold by the trustees, as opportunity may offer, and the estimated amount of the funds necessary to complete such canal or ditch shall be decreased by the estimated value of such lands, previous to the levy and assessment of any tax.

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SEC. 2415. s 13. Where the streams to be taken out for irrigation purposes come from counties other than the one in which the district is situated, but where there are no existing claims to the water and where no individual or settlement will be injured thereby, then the power of said irrigation district is hereby extended to said other county, insomuch as said extension may be necessary for the construction of dams to turn the waters, and ditches or canals with all necessary appurtenances as may be necessary to convey the same to where it is to be used.

SEC. 2416. s 14. Where lakes or ponds in natural basins have outlets, or where such can be made by dams across hollows, such lakes or ponds may be used as reservoirs, to store water for lands lying on lower levels; and the people of any irrigation district may, under the provisions of this act, construct such artificial or use such natural basins for irrigation purposes: *Provided*, The waters of such lakes or ponds are in no case to be raised, by dams or otherwise, so as to interfere with or damage settlers upon the margin thereof.

SEC. 2417. s 15. Upon the construction or partial construction of any canal, ditch, or reservoir contemplated in this act, they shall become the property of the irrigation district; and thereafter all funds necessary for repairs upon said canal, ditch, or reservoir, and for keeping the same in order, or for altering or enlarging the same, may be levied by a tax upon the lands benefited, the landholders in the district to vote upon the same in the manner heretofore provided for in this act. And in case of any sudden emergency, caused by inundation or otherwise, said trustees are hereby authorized and empowered to make such repairs, or take such measures as they may deem necessary to preserve the canals, or ditches or other works of said company or district, and for payment of the expenses so increased the trustees are hereby authorized and empowered to levy a tax for the necessary amount upon all the lands of said district benefited by such canals or ditches, and said tax may be collected in the same manner and at the same time, if necessary, as provided for the collection of other taxes in said district.

SEC. 2418. s 16. All property or money belonging to any irrigation district, in the hands of the trustees to be expended by them under the provisions of this act, is hereby exempted from all city, county, and Territorial taxes.

SEC. 2419. s 17. After any canal or ditch shall have been laid out under this act, or under any special charter where other provision has not been made, the trustees or company may agree with the owners of land through which it will pass for the purchase of so much thereof as may be necessary for the making of the canal or ditch and the appurtenances thereto belonging.

SEC. 2420. s 18. In every case where the owner of the land so required shall absent himself from the country, or shall not, from any cause, be capable in law so to agree, or shall refuse to agree, or ask an exorbitant price, the value of such land and the damages to the owner thereof shall be ascertained in the following manner:

1. The owner of or claimant to such land and the trustees may each select a referee, and in case of disagreement the two may select a third, and these referees shall proceed to determine the value of the land under controversy, and assess the amount of damages, if any, which each owner of lands or improvements has sustained, or will sustain, in consequence of the canal or ditch.

2. The appraisal, with a description of the land so appraised, shall be acknowledged by the referees signing it, before the clerk of the county court of the county in which the lands are situated, and when so acknowledged it shall be filed in the said clerk's office within ten days after it shall have been made. In case the occupant or claimant shall refuse or neglect to select a referee as herein provided, the trustee may petition the district court of the district in which the land is situated for the appointment of three or more commissioners to condemn the land and fix and determine the damages; said commissioners to be appointed upon such notice to the complainant or occupant as said court shall direct. Said commissioners shall report to said court their award and determination for approval or disapproval. The motion for approval of said award shall be heard on such notice as the court shall direct.

SEC. 2421. s 19. The trustees, upon payment to the rightful claimant of the several sums assessed in the appraisal so made, or upon making a tender thereof when the same shall be refused, shall be entitled to enter upon the lands described in the appraisal, and have and hold the same for the use and benefit of such irrigation district forever.

SEC. 2422. s 20. If on any parcel of the lands so described there shall be no person then living authorized to receive payment for the damages assessed for such parcel, and such damages shall not have been lawfully demanded within ten days after the filing of such appraisal, the board of trustees may enter thereon without payment or tender of such damages, but subject to such payment whenever the same shall be thereafter lawfully required.

SEC. 2423. s 21. Any person who, in violation of any right of any other person, or of said corporation, willfully turns or uses the water, or any portion thereof, of said canal, ditch, or reservoir, except at a time or times when the use of such water has

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been duly distributed to such person, or willfully uses any greater quantity of such water than has been duly distributed to him, or in any way changes the flow of water when lawfully distributed for irrigation or other useful purposes, except when duly authorized to make such change, or willfully or maliciously breaks or injures any dam, canal, water-gate, ditch, or other means of diverting or conveying water for irrigation or other useful purpose, is guilty of a misdemeanor.

SEC. 2424. s 22. All companies or districts organized under the provisions of this act shall be liable for any damage which may occur by the breakage of any canal or ditch. When any land in an irrigation district is benefited or damaged by the company's canals or ditches, from soakage or other incidental cause, and the owner of said land and the company can not agree as to the amount of the benefit or damage, the matter in dispute, as well as the question of damage through breakage, may be referred and decided as provided in the preceding section of this act. No irrigation company organized under the laws of this Territory shall be entitled to divert the waters of any stream to the injury of any irrigation company or person holding a prior right to the use of said waters, and all cases of dispute arising from such unlawful diversion may also be referred and decided as provided in section 18 of this act.

SEC. 2425. s 23. Nothing in this act shall be so construed as to interfere with the right of the legislative assembly to repeal, alter, or amend the same at pleasure.

SEC. 2426. s 24. That persons who have constructed canals, ditches, or dams, and taken out water for irrigation purposes before the passage of this act to which this act is amendatory, are hereby authorized to organize under the provisions of said act, and to enjoy all the rights, powers, and privileges guarantied therein: *Provided*, They shall proceed in the same manner as is provided for the organization of new companies.

SEC. 2427. s 25. Nothing in this act shall be so construed as to prevent any association of persons incorporating under the laws of this Territory relating to private corporations for general purposes.

WYOMING IRRIGATION LAWS.

RIGHTS TO USE OF WATER AND RIGHT OF WAY FOR DITCHES.

SEC. 1317. All persons who claim, own, or hold a possessory right or title to any land or parcel of land within the boundary of Wyoming Territory, when those claims are on the bank, margin, or neighborhood of any stream of water, creek, or river, shall be entitled to the use of the water of said stream, creek, or river for the purposes of irrigation and making said claim available to the full extent of the soil for agricultural purposes. [C. L. 1876, ch. 65, § 1.]

SEC. 1318. When any person owning claims in such locality has not sufficient length of area exposed to said streams to obtain a sufficient fall of water to irrigate his land or his farm, or land used by him for agricultural purposes is too far removed from said stream, and he has no water facilities on those lands he shall be entitled to a right of way through the farms or tracts of land which lie between him and said stream, or the farms or tracts of land which lie above and below him, on said stream, for the purposes hereinbefore stated: *Provided*, That, in the construction, keeping up, and using any ditch through the lands of another person, the person or persons constructing or using said ditch, or whose duty it shall be to keep the same in repair, shall be liable to the person owning or claiming such land for all damages accruing to such person by reason of said construction, keeping up, and using such ditch. [C. L. 1876, ch. 65, § 2.]

SEC. 1319. Such right of way shall extend only to a ditch, dike, or cutting sufficient for the purposes required. [C. L. 1876, ch. 65, § 3.]

SEC. 1320. Upon the refusal of the owners of tracts of land, or lands through which said ditch is proposed to run, to allow of its passage through their property, the persons desiring to open such ditch may present to the county commissioners of the county in which said lands are located, a petition, signed by the person or persons describing with convenient accuracy the lands so required to be taken as aforesaid, setting forth the name or names of the owner or other person interested, and praying the appointment of three appraisers to ascertain the compensation to be made to such owner or persons interested. Upon the receipt of said petition, the said county commissioners shall give notice, at least thirty days prior to the appointment of said appraisers, by public notice in a newspaper, when published in the county, or by posting three or more notices in three different places in said county, stating that such appraisers will be appointed on the —— day of ——. [C. L. 1876, ch. 65, § 5.]

SEC. 1321. The said appraisers, before entering upon the duties of their office, shall take an oath to faithfully and impartially discharge their duties as said appraisers. They shall hear the proofs and allegations of the parties, and any two of them, after

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reviewing the premises, shall, without fear, favor, or partiality, ascertain and certify the compensation proper to be made to said owner or persons interested, for the lands to be taken or affected, as well as all damages accruing to the owner or person interested, in consequence of the condemnation of the same, taken or injuriously affected as aforesaid, making such deduction or allowance for real benefits or advantages which such owner or parties interested may derive from the construction of said ditch or flume. They, or a majority of them, shall subscribe a certificate of their said ascertainment and assessment, which shall be recorded in the county clerk's office of the county in which said lands are situated, and upon the payment of the compensation (if any) the said person or persons shall have the right of way to construct said ditch or flume. [C. L. 1876, ch. 65, § 6.]

SEC. 1322. All persons on the margin, bank, neighborhood, or precinct of any stream of water shall have the right and power to place upon the bank of said stream a wheel or other machine for the purpose of raising water to the level required for the purpose of irrigation, and the right of way shall not be refused by the owner of any tract of land upon which it is required, subject, of course, to the like regulations as required for ditches and laid down in the last preceding section. [C. L. 1876, ch. 65, § 7.]

SEC. 1323. The owner or owners of any ditch for irrigation or other purposes shall carefully maintain the embankments thereof, so that the waters of such ditch may not flood or damage the premises of others. [C. L. 1876, ch. 65, § 8.]

SEC. 1324. Nothing in this chapter contained shall be so construed as to impair the prior vested rights of any mill or ditch owner, or other person, to use the waters of any such water course. [C. L. 1876, ch. 65, § 9.]

SEC. 1325. Any ditch company constructing a ditch, or any individual having ditches for irrigation or for other purposes, whenever the same be taken across any publichighway or public traveled road, shall pu a good substantial bridge (not less than fourteen feet in breadth) over such water course where it crosses said road. [C. L. 1876, ch. 65, § 11.]

SEC. 1326. When any such ditch or water-course shall be constructed across any public traveled road, and not bridged within three days thereafter, it shall be the duty of the county commissioners of the county in which said ditch and road are located to put a bridge over said ditch or water-course, of the dimensions specified in the foregoing section, and call upon the owner or owners of the said ditch or water-course to pay the expenses of constructing said bridge, and if payment therefor be refused, a civil action may be maintained for the recovery of the same, together with all accruing costs. [C. L. 1876, ch. 65, § 12.]

SEC. 1327. Upon the refusal of the owner or owners of land or lands through which any person or persons are desirous of constructing any irrigation ditch or ditches, then it shall be lawful for the parties interested to settle the matter by the appointment of a board of arbitration consisting of three men as hereinafter provided. [S. L. 1882, ch. 57, § 1.]

SEC. 1328. The creation of the board of arbitration shall be as follows: The person or persons desiring the construction of such ditch or ditches and the owner or owners of the land or lands through which the construction of such ditch or ditches is contemplated shall each choose one disinterested resident property holder of the county in which the land or lands mentioned above are situated, and the two so chosen shall designate a third person with like qualifications as themselves, and it shall be lawful for these persons to immediately proceed to hear the proof and allegations of the parties concerned. It shall be lawful for any two of such board of arbitration to make such assessment of damages as may in their judgment be deemed just and right, taking into consideration the benefits, if any, that may accrue to the owner or owners of the land or lands through which the construction of such ditch or ditches is contemplated. [S. L. 1882, ch. 57, § 2.]

SEC. 1329. Should the verdict or assessment of such board of arbitration be unsatisfactory to either or both of the parties interested, then recourse may be had by an appeal made in writing within ten days from the rendering of such verdict by such board of arbitration, addressed to the board of county commissioners of the county in which the contestants reside, in which case the party taking the appeal shall give bonds for all the costs; then the case shall stand as though no action had been taken in the matter and the parties may then proceed under this chapter in the same manner as though the proceedings to ascertain the compensation to be given had been taken before the county commissioners in the first instance. [S. L. 1882, ch. 57, § 3.] (For proceedings before commissioners see §§ 1320 and 1321.)

SEC. 1330. In case no appeal be taken as above provided by either of the parties interested, then the nding of such board of arbitration shall be binding and final: *Provided*, The sum of money agreed upon by the board of arbitration has been tendered or paid, or a deed for such right of way executed and delivered or tendered by the party or parties over whose land the right of way is sought. [S. L. 1882, ch. 57, § 4.]

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APPROPRIATION OF WATER AND PROCEDURE.

SEC. 1331. The lands now irrigated, or which may be hereafter irrigated, from ditches taking water from the following described rivers and natural streams of the Territory of Wyoming, are hereby declared to constitute irrigation districts:

District number one shall consist of all lands irrigated from ditches from the North Platte River and its tributaries, except the Laramie River, between its intersection with the boundary line between Nebraska and Wyoming and its intersection with the western boundary line of Laramie County, Crow Creek, Lone Tree Creek, Pole Creek, Horse Creek, Chugwater Creek, Cheyenne River, Niobrara or Running Water River, and their tributaries.

District number two shall consist of all lands irrigated from ditches taking water from the Laramie River and tributaries, except Chugwater Creek, North Platte River and its tributaries, between its intersection with the western boundary line of Laramie County and the mouth of the Sweetwater, Sabille Creek and North Laramie Creek; and also the following-named streams, situate in whole or in part in the county of Albany, namely: Douglass Creek, Lake Creek, the three Beaver Creeks, Four-Mile Creek, Dutton Creek, Cooper Creek, Rock Creek and tributaries, Sabille, Sheep Creek, Deer Creek and tributaries, Antelope Creek, Fish Creek and its tributaries, Dale Creek and its tributaries, and also the following-named lakes, to wit: Cooper Lake, James Lake, Ione Lake, Sportsman's Lake, Lake Hutton, Lake Creighton, Lake George, Steamboat Lake, Horse Creek Lake, Lake Hattie, and Lake Owen.

District number three shall consist of all lands irrigated from ditches taking water from the North Platte River and its tributaries to the line of Carbon County, and all streams or continuations of streams lying within Carbon County.

District number four shall consist of all lands irrigated from ditches taking water from the Green River and its tributaries.

District number five shall consist of all lands irrigated from ditches taking water from the Powder, Tongue, and Big Horn Rivers and their tributaries, except Wind River.

District number six shall consist of all lands irrigated from ditches taking water from the little Powder River, Little Missouri River, and the Belle Fourche and their tributaries.

District number seven shall consist of all lands irrigated from ditches taking water from that portion of Green River lying within Uinta County and Bear River.

District number eight shall consist of all lands irrigated from ditches taking water from Wind River to Johnson County line.

Other irrigation districts may be formed from time to time by the governor, on petition of the parties interested, comprising territory not within any of the above-established irrigation districts. [S. L. 1886, ch. 61, § 1.]

SEC. 1332. There shall be one water commissioner for each of the above-named districts, and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioners so appointed shall hold their office for two years, or until their successor is appointed and qualified. The governor, by like selection and appointment, shall fill all vacancies which may be occasioned by death, resignation, or continued absence form the district, removal or otherwise, and the governor may at any time remove any water commissioner for failure to perform his duties, or for any other cause. [S. L. 1886, ch. 61, § 2.]

SEC. 1333. Within twenty days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe an oath to faithfully and impartially perform the duties of his office, which oath shall be deposited with the clerk of the court having jurisdiction over the priority of rights to use of water in his district. [S. L. 1886, ch. 61, § 3.]

SEC. 1334. It shall be the duty of the said water commissioners to divide the water in the natural stream or streams of their districts among the several ditches taking water from the same, according to the prior rights of each, respectively, in whole or in part, and to shut and fasten, or cause to be shut and fastened, the head-gates of any ditch or ditches heading in any of the natural streams of the district, which in time of a scarcity of water, makes it necessary, by reason of the priority of the rights of others above or below them on the stream. [S. L. 1886, ch. 61, § 4.]

SEC. 1335. Every person who shall willfully open, close, change, or interfere with any head-gate or water-box without authority shall be guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not exceeding one hundred dollars, or imprisoned in the county jail for a term not exceeding six months, or both fine and imprisonment. The water commissioners or their assistants, within their districts, shall have authority to arrest any person or persons offending and turn them over to the sheriff of the proper county. [S. L. 1886, ch. 61, § 5.]

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SEC. 1336. The water commissioners herein provided shall be entitled to pay at the rate of five dollars per day for each day he shall be actually employed in the duties of his office, not to exceed fifty days in any one year, to be paid by the county in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of county commissioners of the county in which his district may be, and said board of county commissioners shall allow the same, and if said irrigation district shall extend into two or more counties then said water commissioner shall present his account for his said services, verified as aforesaid, to the board of county commissioners of the county in which sits the district court having jurisdiction over the priorities of the rights to use of water for the purposes for which it was appropriated in such districts. [S. L. 1886, ch. 61 § 6.]

SEC. 1337. Said water commissioners shall have power, in case of emergency, to employ suitable assistants to aid him in the discharge of his duty; such assistants shall take the same oath as the water commissioner and shall obey his instructions, and each shall be entitled to four dollars per day for every day he is employed, not to exceed thirty-five days in any one year, to be paid upon the certificate of the water commissioner in the same manner as is provided for payment of water commissioners. [S. L. 1886, ch. 61, § 7.]

SEC. 1338. Said water commissioners shall not begin their work until they shall be called on by two or more owners or managers, or persons controlling ditches in the several districts, by application in writing, stating that there is a necessity for their action, and they shall not continue performing services after the necessity therefor shall cease. [S. L. 1886, ch. 61, § 8.]

SEC. 1339. For the purpose of hearing, adjudicating, and settling all questions concerning the priority of appropriation of water, between ditch companies and other owners of ditches, drawing water for beneficial purposes, from the same stream, or its tributaries, within the same irrigation district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested, exclusively in the several district courts, as follows: For district number one, in the district court of Laramie County; for district number two, in the district court of Albany County; for district number three, in the district court of Carbon County; for district number four, in the district court of Sweetwater County; for district number five, in the district court of Johnson County; for district number six, in the district court of Crook County; for district number seven, in the district court of Uinta County; for district number eight, in the district court of Fremont County. All streams, lakes, and reservoirs not herein enumerated shall be, for all purposes, attached to and belong to the irrigation district in which the greater portion of its water is, it being the intent and meaning hereof to add to each irrigation district all waters not hereinbefore enumerated the majority of which lie in their respective areas, for the purposes of acquiring rights to the appropriation and use thereof and adjudicating the same. [S. L. 1886, ch. 61, § 9.]

SEC. 1340. In order that all parties may be protected in their lawful rights to the use of water for beneficial purposes, every person, association, or corporation, owning or claiming any interest in any ditch, canal, or reservoir, within any water district shall, on or before the first day of September, eighteen hundred and eighty-six, if such statements are not already matters of record at the time this act is approved, file with the clerk of the district court having jurisdiction of priority of rights to the use of water for irrigation, in such water district, a statement of claim under oath, entitled of the proper court, which statement shall contain the name or names, together with the post-office address of the claimant or claimants claiming ownership, as aforesaid, of any such ditch, canal, or reservoir, the name thereof (if any), and if without a name, the owner or owners shall choose and adopt a name, to be therein stated, by which such ditch, canal, or reservoir, shall thereafter be known. The description of such ditch, canal, or reservoir as to location of head-gate, general course of ditch, the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water, the length, width, depth, and grade thereof, as near as may be, the time, fixing a day, month, and year, as the date of appropriation of water by original construction, also by any enlargement or extension, if any such thereof have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder, or reservoir, and also the number of acres of land lying under and being, or proposed to be, irrigated by water from such ditch, canal, or reservoir; or if such waters have been appropriated for other beneficial purposes than irrigation, a statement of such purpose; such statement shall be signed by the proper party or parties; and shall file with the county clerk and *ex-officio* register of deeds a like statement, which shall be recorded by him in a book kept for that purpose. [S. L. 1886, ch. 61, § 10.

SEC. 1341. Upon the filing of such statement, the clerk of the court shall indorse upon the back thereof the date of filing, and shall prepare an index of the same, in a

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book to be provided for that purpose by the county commissioners, which said index shall contain the date of filing, the name of the party, association, or corporation, the name of the ditch, the stream from which the water is taken by such ditch, canal, or reservoir, in general terms, the location of the head-gate, the date of the appropriation of the water, by construction, enlargement or extension; said index shall be prepared alphabetically, by reference to the name of the ditch, canal, or reservoir. [S. L. 1886, ch. 61, § 11.]

SEC. 1342. For filing and indexing such statement, the clerk of the court shall receive a fee of one dollar, to be paid by the party or parties filing the same. [S. L. 1886, ch. 61, § 12.]

SEC. 1343. Hereafter every person, company, or corporation, constructing, enlarging, or extending any ditch, canal, or reservoir, for beneficial purposes, and intending to use or appropriate any water from any natural stream within a water district, for such beneficial purposes, shall file with the county clerk and *ex officio* register of deeds and the clerk of the district court, of the proper county, before the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, a statement showing the stream or streams from which the water is to be taken; the point or place on said stream at or near which the water is to be taken out; the line of said ditch or ditches as near as may be; the use or uses to which said water is intended to be applied; the dimensions of such ditch or ditches, and each thereof, giving width on bottom and top, slope of banks, and grade of ditch; and likewise of any and all enlargements thereof; which statement shall be filed and indexed as is provided in section thirteen hundred and forty, and from the time of filing any such statement water sufficient to fill such ditch or ditches, and to subserve the use or uses aforesaid, if a lawful and just use, shall be deemed and adjudged to be appropriated: *Provided*, That nothing herein contained shall be permitted to interfere with a prior right to said water, or to any thereof; *And provided further*, That such person or persons, or corporation, shall, within sixty days next ensuing the filing of such statement, begin the actual construction of said ditch or ditches, and shall prosecute the work of the construction thereof diligently and continuously to its completion; *And provided further*, That the beginning of all necessary surveys of such ditch shall be construed as the beginning of said work of construction. [S. L. 1886, ch. 61, § 13.]

SEC. 1344. The water of every natural stream not heretofore appropriated within this Territory is hereby declared to be the property of the public and the same is dedicated to the use of the people, subject to appropriation as herein provided. The provisions of this chapter shall apply to all cases where water of natural streams is appropriated for beneficial purposes, whether the water be conducted through ditches, canals, flumes, or tunnels, and shall apply also to cases where for irrigation purposes the water is stored in reservoirs, and the owner or owners of any ditch, canal, flume, or tunnel through which water is conducted for irrigation purposes, and also the owners of reservoirs, may conduct the water therefrom into and along any of the natural streams of the Territory, but not so as to raise the waters thereof above high-water mark, and may take the same out again at any point desired, but due allowance shall be made for evaporation and seepage, the amount to be determined by the water commissioner of the proper district, subject to review and determination by the court having jurisdiction over priorities in such district. [S. L. 1886, ch. 61, § 14.]

SEC. 1345. Whenever any person or persons, association or corporation, interested as owners of any ditch, canal, or reservoir, in any district, shall desire a determination of the priorities of rights to the use of water from stream or streams from which they draw the water for their ditch or ditches, canals or reservoirs, they shall present to the district court having jurisdiction over the rights in such water district, or to the judge thereof in vacation, a motion, petition, or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to the use of water for irrigation between the several ditches, canals, or reservoirs in such district on the stream or streams named in the motion, petition, or application. The said motion, petition, or application shall state the names of the ditches, canals, or reservoirs claiming water from said stream or streams, as appears by the final statements in the clerk's office, together with the names of the persons, associations, or corporations interested therein, taken from said statements, and shall set forth the nature of the claim or claims of the applicant or applicants, and such motion, petition, or application shall be entitled "In the matter of an application for an adjudication of the priorities of rights to use water for beneficial purposes in water district number ——, on ———" (stating the stream or streams). Upon the filing and docketing of such application the court, or judge thereof in vacation, shall without unnecessary delay, by an order to be entered of record, upon such motion, petition, or application, appoint a day, in some regular term of said court, or in vacation thereof, for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court, or judge thereof in vacation, to proceed and hear all evidence that may be offered by or in behalf of any person, association, or corporation interested in such stream or streams in such district in any ditch, canal, or res-

ervoir, either as owner or consumer of water therefrom, in support of or against any claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by an enlargement or extension thereof in such district, or on such stream or streams, and consider all such evidence, also the arguments of the parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof, as originally constructed, the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned, the time spent severally in such construction, enlargement, or extension and re-enlargement, if any, the diligence with which the work was in each case prosecuted, the nature of the work as to the difficulty of construction, and all such other facts as may tend to show the compliance with the law in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right by appropriation of water of the several ditches, canals, and reservoirs in such water district in such stream or streams concerning which testimony shall have been offered, each according to the time of its said construction and enlargement or enlargements and extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargement or extensions, describing such amount by cubic feet per second of time (which shall also be the method of measurement for the sale of water), if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir in such decree. Such court, or judge thereof in vacation, shall further order that each and every person interested or claiming any such ditch, canal, or reservoir shall receive from the clerk, on payment of a reasonable fee therefor, to be fixed by the court, or judge in vacation, a certificate, under seal of the court, showing date or dates, and amount or amounts, of appropriations adjudged in favor of such ditch, canal, or reservoir, under and by virtue of the construction, extension, and enlargement thereof severally, also specifying the number of said ditch as determined by the court with reference to priority, and of each priority to which the same may be entitled by reason of said construction, extension, and enlargement: *Provided*, That any party or parties claiming any right to the use of water for beneficial purposes in such district, and on such stream or streams, by reason of being owner of or interested in any ditch, canal, or reservoir, who is not mentioned in the motion, petition, or application filed and presented to the court, shall be notified by the clerk of such application, and shall become parties to such proceedings, and shall have their rights adjudicated therein. The court or judge thereof, in vacation, may, instead of taking the testimony orally or in open court, refer the matter to some person to take and reduce to writing the testimony to the court, or judge thereof in vacation, and the person to whom such cause shall be referred for that purpose shall have the same power and duties concerning the taking of testimony and compelling the attendance of witnesses as masters in chancery. [S. L. 1886, ch. 61, § 15.]

SEC. 1346. Upon the order of the court fixing the time of hearing being made, the clerk shall place a certified copy of such order, which order shall contain the names of all the parties alleged in application to be interested in the matter in the possession of the sheriff of the proper county, which shall be thereupon served upon each of the parties therein named in the same manner as a summons, and a return of the service shall be made and filed with the clerk within fourteen days after the delivery of said order to the sheriff, or if served by any other person, in cases where a summons could be served, then return shall be made within fourteen days after date of order. It shall be the duty of the clerk also to give public notice of such application and order, by publication in a newspaper, if any be printed and in circulation, in some county wherein such water district is situated, which notice shall be published at least once each week for two consecutive weeks, and which said notice shall contain the date of the filing of said motion, petition, or application, the name or names of the parties filing the same, a copy of the order made by the court for hearing, and shall notify all parties interested as owners in any ditch, canal, or reservoir on such stream or streams in such water district, as well as the persons named in the motion, petition, or application, to appear at said court, or before the judge thereof in vacation, at the time appointed and stated in the order, and that all persons interested as owners or consumers may then and there present his, her, or their proofs for or against any priority of right of water by appropriation sought to be shown by any party by or through any ditch, canal, or reservoir (either as owner or consumer of water drawn therefrom), and in case any party mentioned in the motion, petition, or application can not be personally served in any county embraced in such water district, the published notice above provided shall be deemed sufficient service of notice: *Provided further*, That in addition to such publication the clerk shall mail

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such published notice to each party mentioned in the motion, petition, or application, directing the same to the address of such parties as stated in the sworn statement on file. Proof of the proper publication shall consist in the sworn certificate of the publisher of the paper in which notice is published, to which shall be attached a printed copy taken from such paper. [S. L. 1886, ch. 61, § 16.]

SEC. 1347. Any person or persons who shall knowingly and willfully cut, dig, or break down, or open any gate bank, embankment, or side of any ditch, canal, or reservoir, flume, tunnel, or feeder in which such person or persons may be joint owners, or on the property of another, or in the lawful possession of another or others, and used for the purpose of irrigation, milling, manufacturing, mining, or domestic purposes, with intent maliciously to injure any person, association, or corporation, or for his or her own gain, unlawfully, with the intention of stealing, taking, or causing to run, or pour out of such canal, or reservoir feeder, or flume, any water for his or her own profit, benefit, or advantage, to the injury of any other person, persons, association, or corporation lawfully in the use of such water, or of such ditch, canal, tunnel, feeder, or flume, he, she, it, or they, so offending, shall be deemed guilty of a misdemeanor, and, on conviction thereof, shall be fined in any sum not exceeding one hundred dollars, and may be imprisoned in the county jail not exceeding six months, or both, at the discretion of the court. [S. L. 1886, ch. 61, § 17.]

SEC. 1348. Any party or parties, representing any ditch, canal, or reservoir, or any number of parties, representing two or more ditches, canals, or reservoirs, which are affected, in common with each other, by any portion of the decree rendered by the district court, by which he, she, it, or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining, desiring an appeal, shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common, adversely to the interests of appellants, shall be appellees. The party or parties in such appeal shall, within sixty days after the date of the decree, file in the district court wherein any decree is entered under this chapter a notice of appeal in writing, stating that such party or parties appeals to the supreme court of the Territory from the decree rendered in the case, or any part thereof. When only a part of the decree is appealed from the notice of the appeal should so state, and shall also in that case specify the portion or part of the decree appealed from. Upon filing of such notice of appeal the cause shall be deemed to be appealed to the supreme court of the Territory: *Provided, however*, That the party or parties appealing as aforesaid, shall, within sixty days aforesaid, enter into an undertaking, to be approved by the district court, or judge thereof, and to be given to all parties in said suit or proceeding, other than the parties appealing, and to be in such an amount as the court or said judge shall fix, conditioned that the parties giving their said undertaking shall prosecute their appeal to effect, and without unnecessary delay, and will pay all costs and damages which the parties to whom the undertaking is given, or either or any of them, may sustain in consequence of such appeal. [S. L. 1886, ch. 61, § 18.]

SEC. 1349. The order last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the appellees, by delivering the same to him or her, if he or she may be found, or otherwise serving the same, in manner the same, as may be provided for serving summons from the district court by the laws then in force. [S. L. 1886, ch. 61, § 19.]

SEC. 1350. The appellant or appellants shall within six months after the appeal be allowed as aforesaid, file in the office of the clerk of the supreme court of this Territory a certified transcript of the proceedings had in the case in the district court, containing the pleadings and the statements of the parties filed herein and all evidence of record offered on the hearing of the cause, or so much thereof as shall effect the appropriation of water claimed by the means of construction, enlargement, or re-enlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal. When the evidence has been taken in the open court, or before the judge, in vacation, such evidence, or the substance thereof, reduced to writing and signed by the judge, or in case notes of said testimony have been taken by the official stenographer, a transcription of the same, signed by the stenographer and attested by his official seal, filed with the clerk of the court, shall be deemed a record of the evidence taken in said court. [S. L. 1886, ch. 61, § 20.]

SEC. 1351. The supreme court, in all cases heard before it under this chapter, shall, where it can properly be done, render such decree as the court, or the judge below, should have rendered. It may either reverse or modify the decree of the court or judge below, and in cases where the decree of the court below is reversed, in whole or in part, it may direct the court below as to its further proceedings therein. [S. L. 1886, ch. 61, § 21.]

SEC. 1352. No claim of priority of any person, association, or corporation on account of any ditch, canal, or reservoir, as to which he, she, it, or they have failed or refuse to offer evidence, under any adjudication herein provided for, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until

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such time as such party shall have by application to the court having jurisdiction obtained leave and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which leave shall be granted in all cases upon terms as to notice to other parties interested, and upon payment of all costs, and upon affidavit or petition sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof, against which such priority is claimed, nor until a decree adjudging such priority to such ditch, canal, or reservoir has been entered, and certificate such as mentioned in section thirteen hundred and forty-six shall have been issued to claimant and presented to the water commissioner. [S. L. 1886, ch. 61, § 22.]

SEC. 1353. No person, association, or corporation representing any ditch, canal, or reservoir shall be permitted to give or offer any evidence before said court until he, she, it, or they shall have filed a statement of claim in substance the same in all respects as is required to be filed under the provisions hereof. [S. L. 1886, ch. 61, § 23.]

SEC. 1354. The district court, or judge thereof in vacation, shall have power to order for good cause shown, upon terms just to all parties, and in such manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this chapter, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved, that the ends of justice will be thereby promoted, but no such review or re-argument shall be ordered unless applied for by petition or otherwise within two years of the time of entering the decree complained of. [S. L. 1886, ch. 61, § 24.]

SEC. 1355. Persons desiring to construct and maintain reservoirs for the purpose of storing water shall have the right to take from any of the natural streams of the Territory and store away any unappropriated water not needed for immediate use, for domestic or irrigation or other beneficial purposes, to construct and maintain ditches, canals, flumes, or tunnels, for carrying such water to and from such reservoirs, ditches, canals, tunnels, and flumes, in the same manner provided by law for the condemnation of lands for right of way for ditches: *Provided*, No reservoir with embankments or a dam exceeding ten feet in height shall be made without first submitting the plans thereof to the county commissioners of the county in which it is situated, and obtaining their approval of said plans: *And provided further*, That no such reservoir shall be constructed or made in or across the channel of any natural and running stream. [S. L. 1886, ch. 61, § 25.]

SEC. 1356. The owners of reservoirs shall be liable for all damage arising from leakage or overflow of the waters therefrom, or by floods caused by breaking of the embankments of such reservoir. [S. L. 1886, ch. 61, § 26.]

SEC. 1357. Every witness who shall attend before the court, or the judge thereof in vacation, or before the person appointed to take testimony, in the causes provided for in this chapter, under subpœna, by request of any party, shall be entitled to the same fees and mileage as witnesses in civil cases in the district court, and shall be paid by the party requiring his testimony. [S. L. 1886, ch. 61, § 27.]

SEC. 1358. It shall not be necessary for any corporation heretofore organized and now existing, or for any corporation hereafter organized, under the laws of this Territory, which has heretofore, or shall have hereafter constructed, operated, or maintained any ditches, canals, flumes, tunnels, or reservoirs, or other appropriations of water, for the purpose of irrigation, mining, manufacturing, domestic uses, or for any beneficial purpose whatever, to incorporate as a ditch company, or companies, if the objects or purposes for which such corporation shall have been formed or incorporated, imply, permit, or make necessary, or advantageous, such use or uses of water; and such corporation for all the purposes of this chapter shall have all the rights of a natural person as defined herein, and shall have its rights determined in the same manner: *Provided*, No priority of water right shall take from any city or town the water required for the use of the residents thereof. [S. L. 1886, ch. 61, § 28.]

SEC. 1359. Said water commissioners shall so divide, regulate, and control the use of the water of all streams within their respective districts in such manner, as near as may be, as will prevent unnecessary waste of water, and to that end such commissioners shall so shut and fasten the head-gate or gates of all ditches so that no more water will flow into said ditch than is actually required and will be used for the uses or purposes for which such water was appropriated, and any person who may be injured by the action of any water commissioner or by his failure to act pursuant to this chapter, may resort to any court of competent jurisdiction for such relief as he may be entitled to. [S. L. 1886, ch. 61, § 29.]

SEC. 1360. It shall be the duty of every person, corporation, or company, who shall construct, maintain, or operate any ditch or canal under the provisions of this chapter to construct and maintain, at the point and place where the water is diverted from its natural channel, some fit and proper obstruction whereby all fish will be prevented from entering said ditch or canal. Any person, company, or corporation violating the provisions of this section shall be adjudged guilty of a misdemeanor, and

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on conviction thereof shall be punished by a fine of not more than one hundred dollars or by imprisonment in the county jail not less than ten nor more than sixty days, or by both such fine and imprisonment. [S. L. 1886, ch. 61, § 30.]

SEC. 1361. This chapter shall in no wise be construed as impairing or abridging any rights already vested in any person or persons, company or corporation, by virtue of the law heretofore in force. [S. L. 1886, ch. 61, § 31.]

IRRIGATION—APPROPRIATION OF WATER—TERRITORIAL ENGINEER.

SECTION 1. There shall be a Territorial engineer, who shall be appointed by the governor, by and with the consent of the legislative council; he shall hold his office for the term of two years, commencing on the first day of April, A. D. eighteen hundred and eighty-eight, and until his successor shall be appointed and shall have qualified.

The governor may at any time, upon good cause being shown, remove the Territorial engineer, and fill the vacancy occasioned by such removal from office.

The Territorial engineer shall receive a salary of two thousand and five hundred dollars per annum, payable in monthly installments by the Territorial treasurer, upon warrants drawn by the Territorial auditor.

The Territorial engineer shall keep his office at the Territorial capitol, in a room in the capitol building, to be set aside for his use by the governor.

Before entering upon the duties of his office he shall take and subscribe an oath before some officer authorized by the laws of this Territory to administer oaths, to faithfully perform the duties of his office, and file with the secretary of the Territory said oath and his official bond, in the penal sum of five thousand dollars, with not less than two sureties to be approved by the governor of the Territory, and conditioned for the faithful discharge of the duties of his office, and for delivering to his successor, or other officer appointed by the governor to receive the same, all moneys, books, and other property belonging to the Territory then in his hands, or under his control, or with which he may be legally chargeable, as such officer. No person shall be appointed as such Territorial engineer who is not known to have such theoretical knowledge and practical skill and experience as shall fit him for the position.

SEC. 2. The Territorial engineer shall have general supervision of the diversion and division of the water of the various natural streams in the Territory, and shall have supervision of the work of the water commissioners of the different water districts of the Territory, and shall do and perform any and all work for the Territory which comes within the nature of his profession as an engineer, when called upon by the governor to do so.

SEC. 3. The Territorial engineer shall make, or cause to be made, careful measurements and calculations of the maximum, minimum, and ordinary flow, in cubic feet per second of time, of the waters flowing in each stream from which water shall be drawn for irrigation purposes, commencing such work upon those streams most used for irrigation; he shall collect facts and make a report as to a system of reservoirs for the storage of waters in those portions of the Territory where such a system is practicable, stating in such report the location, capacity, and cost of such reservoirs; he shall become conversant with the water-ways of the Territory, and needs of the Territory as to irrigation matters, and in his report to the governor he shall make such suggestions as to the amendment of existing laws, or the enactment of new laws, as his information and experience may suggest; and he shall keep full and proper records of his works, observations, and calculations, all of which shall be the property of the Territory.

SEC. 4. The Territorial engineer shall, on request of any party interested, measure and ascertain the carrying capacity of any ditch used for irrigation or other beneficial purposes, which may be now or which may hereafter be constructed or enlarged, and give to the party or parties requiring such services an official certificate of the size and carrying capacity of such ditch, expressed in cubic feet per second of time, as he shall find it at the time of measuring the same. For such services he shall be entitled to receive from the party or parties requiring the same his per diem charges, not exceeding ten dollars per day, and his reasonable traveling expenses: *Provided*, That all per diem charges for such services received by the Territorial engineer shall be delivered by him to the Territorial treasurer, who shall credit the same to the general fund. If the applicant or applicants for such engineer's certificate shall state in writing to the engineer that the ditch to be measured is so remote from the office of the engineer as to render the expense of the engineer's personal examination too great, or if in the engineer's judgment such ditch is too far distant to prevent him, consistently with his public duties, to make such personal examination, it shall in such cases be his duty to appoint some competent civil engineer residing in the vicinity of such ditch to make a sworn statement, setting forth the width on top and bottom, depth, grade, and slope of the bank of such ditch or its enlargement, and all such other data concerning such ditch so to be measured as the Terri-

torial engineer shall direct. Such civil engineer shall receive for his services such sum as may be agreed upon between himself and the party requiring his services, but in the absence of any agreement in writing such compensation shall not exceed ten dollars per day and his reasonable traveling expenses. The Territorial engineer shall furnish the person so appointed with blank certificates upon which to enter the necessary data concerning the ditch or its enlargement so to be measured, which blank shall be properly filled out and verified by the oath of the party making such measurements and returned to the Territorial engineer, who shall make his own calculations of the carrying capacity of such ditch or enlargement, expressed in cubic feet per second of time, and certify to the same. The certificates provided for in this section shall set forth the time of making the measurement, the location of the headgate of the ditch measured, the name of the natural stream of water from which such ditch draws its supply of water, the width of such ditch both on top and on bottom, its depth and grade, and its carrying capacity expressed in cubic feet per second of time, and also the name of the ditch and of the owner or owners thereof, if known. All such certificates shall be recorded at length in the office of the said Territorial engineer, and copies of such record, duly certified to by the said engineer, shall be received in all the courts of this Territory as prima facie evidence of the fact therein set forth as hereby required.

SEC. 5. The Territorial engineer, with the consent of the governor, shall have power to employ assistants at an expense not to exceed one thousand dollars in any one year, who shall be paid out of any moneys appropriated for that purpose, on the certificate of said Territorial engineer, approved by the governor, showing the reason for such employment, the services rendered, and the amount thereof, and on presentation of such certificate to the Territorial auditor, by the person entitled thereto, he shall issue his warrant on the Territorial treasurer for the amount thereof to be paid out of any appropriations, as aforesaid, and not otherwise.

SEC. 6. When the Territorial engineer is called away from his office in the discharge of his public duties he shall be entitled to his actual traveling expenses, which shall be paid out of any money appropriated for that purpose, on the certificate of the said engineer; such certificate shall be presented by the said engineer to the Territorial auditor, who shall thereupon draw his warrant upon the Territorial treasurer for the amount thereof, to be paid out of such appropriation: *Provided*, That this section shall not be so construed as to authorize the payment of traveling expenses to said engineer when called away from his office to perform any of the work mentioned in section four of this act.

SEC. 7. The appropriator of any of the public waters in this Territory shall construct and maintain, under the direction of the Territorial engineer, a flume or other measuring device, at or as near the head of his ditch as is practicable, for the purpose of assisting the water commissioners in determining the amount of water that may be turned into the ditch or the amount that may be by his ditch diverted from the stream. In case any owner or appropriator of public waters that have been adjudicated upon neglect or refuse to put in such measuring device, after thirty days' notice to do so by the Territorial engineer, the said engineer may direct the water commissioner, of the district in which the ditch may be situate to put in such flume or measuring device, which being done by the water commissioner, he, the said commissioner, shall present the bill of the cost of such flume or measuring device to the owner or owners of the ditch, and if such owner or owners shall refuse or neglect, for three days after presentation of such bill, to pay the same, the said water commissioner may maintain a civil action in his own name, in any court of the Territory, for the recovery of the same, with all accruing costs. Said suit shall be prosecuted by the county and prosecuting attorney for the county wherein such suit may be brought, free of any charge against said commissioner.

SEC. 8. The Territorial engineer shall prepare and render to the governor yearly, and oftener if required, full and true reports of his work, touching all the matters and duties devolving upon him by virtue of his office, which report shall be delivered to the governor on or before the thirtieth day of November in each year, in order that the same may be laid before the legislative assembly at its regular sessions.

SEC. 9. In all cases in which the priorities to the right to the use of the waters of any of the streams of this Territory have been adjudicated by any of the district courts of this Territory under the provisions of chapter two of title nineteen of the Revised Statutes of Wyoming, it shall be the duty of the clerk of the district court wherein said adjudication may have been made to forward a certified copy of such decree to the Territorial engineer immediately after the rendering of a decree in the matter of such adjudication, and for such copy there shall be paid to the said clerk, out of the treasury of the county wherein such decree was rendered, compensation at the rate of ten cents for each one hundred words contained in such decree. On receipt of such copy of such decree it shall be the duty of the Territorial engineer to cause the same to be recorded at length in a suitable book, to be provided for that purpose, and as soon thereafter as practicable to forward to the water commissioner

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of the water district wherein the stream adjudicated upon is situated a statement showing the title of the court in which such decree was rendered, the date of the decree, the name of each ditch the priority of which has been by such decree determined, its capacity, showing the width, depth, and grade of the said ditch and the quantity of water per second of time to which said ditch is declared by such decree to be entitled, to be expressed in cubic feet per second of time, and thereafter, in the supervision of the distribution of the waters of such streams by said ditches so adjudicated upon, it shall be the duty of the said water commissioner to be guided by such statement. It shall be the duty of the Territorial engineer to procure and cause to be recorded in his office a description of the flume or other measuring device at the head of each ditch so adjudicated upon, showing the width, depth, and grade of each flume or other measuring device, and to calculate and determine the quantity of water, expressed in cubic feet per second of time, which will flow through such flume or other measuring device at various depths, and furnish the proper water commissioner with a statement of the same.

SEC. 10. The water of every natural stream not heretofore appropriated, within the Territory of Wyoming, is hereby declared to be the property of the public, and the same is hereby dedicated to the use of the people of said Territory, subject to appropriation as hereinafter provided.

SEC. 11. Every person, company, or corporation hereafter constructing, enlarging, or extending any ditch, canal, or reservoir for irrigation or other beneficial purposes, and intending to use or appropriate any water from any natural stream within a water district for such purposes, shall, within ninety days after the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, file and cause to be recorded in the office of the county clerk and *ex-officio* register of deeds of the county in which is situated the district court having jurisdiction of all questions concerning the priority of rights to the use of water in such water district, a statement of claim under oath, setting forth the name or names, together with the post-office address of the owner or owners of any such ditch, canal, or reservoir; the name thereof, if any, and if without a name, the owner or owners shall adopt a name to be therein stated by which such ditch, canal, or reservoir shall thereafter be known; the number of the water district in which the same is situated; a description of such ditch, canal, or reservoir, as to location of head-gate and the general course of such ditch; the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water; the length, width at top and bottom, depth, grade, and carrying capacity thereof, expressed in cubic feet per second of time, as near as may be; the time, giving the day, month, and year when work was commenced thereon by original construction, enlargement, or extension, as the case may be, and likewise the date when water was actually appropriated therefrom for irrigation and other beneficial purposes; the number of acres lying under and being, or proposed to be, irrigated by water therefrom, and a map or plat on a scale of not less than one inch to the mile, showing the location of route of such ditch, canal, or reservoir, and the natural stream from which it draws its supply of water, and also the legal subdivisions of land through which they flow: *Provided*, That in case the said statement gives the direction or route of such ditch by courses and distances, according to the field-notes of the survey thereof, it shall not be necessary to include in any such statement the map or plat above referred to. Such statement shall be signed by the person owning such ditch, canal, or reservoir, or, in case of a copartnership, by any member thereof, for and in behalf of such copartnership, or in case of a corporation, by the president or secretary thereof, and such statement shall be recorded as aforesaid in a book to be kept for that purpose.

SEC. 12. If the owner or owners of any such ditch, canal, or reservoir shall prosecute the work of construction thereon diligently and continuously until completed, and shall otherwise comply with the provisions of law, such owner or owners shall, as regards the owner or owners of all other ditches subsequently constructed and drawing their supply of water from the same stream, have a priority of right to the use of such water from and after the date of the commencement of the construction thereof, but not otherwise. The beginning of all necessary surveys of such ditch shall be considered as the commencement of such work of construction.

SEC. 13. When the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purpose shall have preference over those claiming water for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes.

SEC. 14. The priority of right to the use of such water shall be limited and restricted to so much thereof as may be necessarily used and appropriated for irrigation or other beneficial purposes as aforesaid, irrespective of the carrying capacity of the ditch, and all the balance of the water not so appropriated shall be allowed to run in the natural stream from which such ditch draws its supply of water, and shall not be considered as having been appropriated thereby; and in case the owner or owners

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of any such ditch, canal, or reservoir shall fail to use the water therefrom for irrigation or other beneficial purposes, or shall refuse to furnish any surplus water to the owner or owners of lands lying under such ditch as hereinafter provided, during any two successive years, they shall be considered as having abandoned the same, and shall forfeit all water rights, easements, and privileges appurtenant thereto, and the waters formerly appropriated by them may be again appropriated for irrigation and other beneficial purposes the same as if such ditch, canal, or reservoir had never been constructed; neither shall the owner or owners of any such ditch, canal, or reservoir have any right to receive from others any royalty for the use of the water carried thereby, but every such owner or owners having a surplus supply of water and furnishing the same to others from any ditch, canal, or reservoir as hereinafter provided, shall be considered common carriers and shall be subject to the same laws that govern common carriers.

SEC. 15. The owner or owners of any such ditch which carries a greater quantity of water than the owner or owners thereof necessarily use for irrigation and other beneficial purposes in connection with their own lands shall, when application is made to them for that purpose, furnish such surplus water at reasonable rates to the owners of lands lying under any such ditch for the purpose of reclaiming such lands and rendering the same productive, and in case of refusal so to do the owner or owners of any such ditch may be compelled by injunction suit to furnish such water on such terms as to the court may seem meet and proper: *Provided*, That the board of county commissioners in their respective counties shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for the use of water, whether furnished by individuals or corporations.

SEC. 16. The cubic foot of water per second of time shall be the legal standard for the measurement of water in this Territory, both for determining the flow of water in natural streams and ditches and also for the purpose of distributing water therefrom.

SEC. 17. Nothing in this act contained shall in any wise interfere with any prior right to the use of said water; neither shall the owner or owners of any such ditch, canal, or reservoir who have heretofore complied with the laws relating thereto enacted by the ninth legislative assembly of Wyoming be required to file any additional statement of claim under the provisions of this act.

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IRRIGATION, ANCIENT AND MODERN.

ITS PHYSICAL FEATURES AND CHARACTERISTICS.

POSSIBLE EVIL EFFECTS—PRINCIPLES OF LEGISLATION IN ANCIENT TIMES—ITALY—SPAIN—FRANCE—MEXICO—AUSTRALIAN LEGISLATION—DEAKINS' REPORT—EGYPT.

PART VI.

Irrigation of land is an art that existed for many centuries previous to any authentic written history. The traditions of the Chinese people are very ancient, and irrigation is mentioned in their earliest history as extensively practiced. In Egypt, Syria, and the ancient kingdoms of Eastern Asia agriculture depended almost wholly upon irrigation, and still so depends in those countries where the people have survived the political changes of thousands of years. The irrigation of gardens, vineyards, and fields is frequently mentioned in the Scriptures; one of the earliest books speaks of it, and one of the prophets refers to "furrows of the plantation." The systems adopted in California, Texas, New Mexico, and Colorado are of ancient origin, and are copied from ancient models. They are not the best, but they are cheap and easy of construction. The settlement of the drier regions of our territory adds another instance to those of past history. The actual history of irrigation in the United States begins with the construction of the Pacific railroads.

The enormous sums expended by the British Government in India in irrigating works, and the profit derived from them will serve to sustain the arguments put forth by Mr. Cole and others, that while Great Britain is engaged in India not only in the construction of reservoirs for the storage of the waters and streams, but for gathering in the rains and dews for the purposes of irrigation, spending millions annually in such works, and in keeping them in repair, our own country, possessing vaster domains than any nation of the world, and of incomparable value, has only to enter upon her own possessions and, by trenching her mountain sides, beget reservoirs as enduring as the foundations of the earth.

USES, ABUSES, AND REMEDIES.

The late Hon. George P. Marsh, for many years United States minister to Italy, in an exhaustive article on "IRRIGATION, ITS EVILS, THE REMEDIES, AND THE COMPENSATIONS," treats on all the phases of this important subject. In this article Mr. Marsh refers to the customs and laws governing the use of water in every country of Europe. The methods of accumulating and distributing the water of precipitation, and of flooding springs and streams for agricultural purposes, are readily accessible, and in the practical employment of the system our engineers and the ingenuity of our people will, he says, no doubt overcome any special difficulties arising from the peculiar geographical and me-

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teorological features of our territory. The social, legal, sanitary, and financial aspect of the subject in its application to extensive tracts of cultivated land are not familiar to the American public. He says, cautions of a not altogether obvious nature are more needed than instruction on points of practical method, or of adaptability to particular branches of agriculture. He points out the evils and difficulties of the practice of irrigation, and suggests precautions against the occurrence of these evils and the means of palliating them where they are to some extent inevitable. In the introduction of new systems of industrial or rural occupation in a scale large enough to affect the rights and interests of whole classes of the population, equal regard should be paid to the good of every class, and on all such occasions the moral, social, and sanitary consequences of great changes in the habits and employments of large bodies of the people is of more consequence than the merely financial results. In this, as in most questions of political economy, is encountered the great enigma of the right relation between capital and labor, and there are not many instances where these relations are more unsatisfactory than in the employment of irrigation on the great scale in which it is practiced in many parts of Europe. Mr. Marsh says the tendency of irrigation in the Old World as a regular agricultural method is to promote the accumulation of large tracts of land in the hands of single proprietors, and consequently to dispossess the smaller land-holders. Where a district derives its supply of water for irrigation from a single stream or lake not practicably inexhaustible, the interests of production require that the husbandry of the entire district be administered in a uniform or harmonious system, and consequently that the control of the source of water-supply be vested in a single head; for it is obvious that each land-holder can not be allowed to draw off at his pleasure and appropriate to his own use the whole current or such parts of it as may suit his convenience. The cause, capacity, and channels of division and of final discharge must be determined by some common principle, and adapted to the branches of husbandry best suited to the soil and climate. The agricultural economy of each farmer must remain substantially fixed and invariable, and even so simple a thing as the rotation of crops would be almost impracticable, because it would be impossible to change the whole system of supply. The canals of diversion and distribution once established, the net-work must remain immutable, "as the arteries and veins of the human system." The measurement of flowing water and its diversion between different occupants are matters of extreme complexity, and jealousies and dissensions often arise between neighboring claimants in regard to the ascertainment of the quantity rightfully belonging to each and the amount actually withdrawn by each from the common source of supply. The consequence of these interminable vexations is that the poorer or more peaceably disposed land-holder is obliged to sell his possessions to a richer proprietor, and the whole district gradually passes into the hands of a single holder, family, or corporation. In the large irrigated plain lands of Europe real estate is accumulated in vast tracts of single ownership, and farming is conducted on a scale hardly surpassed in England or even on the almost boundless regions of our own West. In illustration of this Mr. Marsh states that ten years ago a single proprietor exhibited at an agricultural fair at Modena one hundred yoke of oxen from his own estate. There are doubtless, he says, considerable economical advantages in the system. The unity of administration tends to increase production as well as to diminish the cost, but the evils more than counterbalance this advantage. Pliny, the elder, complained eighteen hundred years ago that great farms had been the ruin

of Italy. Next in importance to the moral and social aspects of the system comes the question of the effects of irrigation on the health of the population employing it in certain branches of agriculture where water is largely used. The fact is established that the miasmatic exhalations are highly deleterious. The rice grounds of Lombardy are almost as destructive to health as those of Georgia and other Southern States. All irrigation, Mr. Marsh says, except where the configuration of the surface and the character of the soil are such as to promote the rapid draining of the water, or where special precautions are provided against its influence, is prejudicial to health. The increased dampness of the atmosphere is injurious to the respiratory system in some localities, and in others the exhalations from the watered soil and moistened manure tend to develop malarious influences, and aggravate, if not occasion, febrile diseases. Mr. Marsh says, in a foot-note:

There is no doubt the insalubrity of Rome is greatly aggravated by the abundantly irrigated gardens within the walls of that city, and the increased prevalence of malarious fevers in the neighborhood of New York and other American cities is due to increased extent of market gardens, and consequently of irrigated lands in their vicinity.

INFILTRATION OF THE SOIL.

Mr. Marsh notices the purely physical evils which he regards as in many cases inseparable from this system of husbandry, and says the first and most obvious effect of withdrawing water from its narrow natural channels and distributing it over the surface of the earth is a great increase in the humidity of the soil watered, a like increase in the evaporation from it, and a corresponding reduction of the atmospheric temperature, as in other cases of evaporation. The water imbibed by the earth is generally estimated at about one-seventh of the quantity applied. This may not be sufficient to affect the consistence of the soil to a serious degree, but of the remaining six-sevenths the portion not carried off by evaporation, employed to irrigate lands at a lower level, or discharged into running streams or lakes, frequently produces a very prejudicial effect on the soil of adjacent lands over which the water flows or into which it percolates. Thus, he says, the infiltration of the superfluous water from the rice grounds of Lombardy sometimes renders the lower fields adjacent unfit for any other husbandry to a distance of miles from the land flowed for watering the rice. The division of brooks and rivers and the final discharge of the current by remote outlets tends to deprive the district originally watered by it of their proper supply, and while on the one side considerable tracts of land are sometimes drenched with superfluous moisture, on the other water-courses large enough to drive mills and other machinery may be laid dry and their fish destroyed, and even the subterranean conduits from their beds which fed the springs and wells at lower levels may cease to flow.

Irrigation always compacts and hardens the soil, and frequently to a very inconvenient degree. This, of course, increases the labor both of plowing and the subsequent tillage with hoe or cultivator, and farmers are tempted to rely too much on the fertilizing power of irrigation, and consequently to use little manure, a liberal application of which renders land less liable to become hard and tenacious by watering. A general opinion prevails that water employed for irrigation dissolves some of the fertilizing ingredients of the soil, and carries them with it in its flow or percolation through the adjacent fields into which it escapes. This opinion was controverted by Liebig, who taught that none of the material constituents of vegetation were thus abstracted by water, and that view has been confirmed by other observers. But later experiments appear to show that the doctrines of Liebig and his followers are not

strictly true, for mineral and vegetable substances, which enter more or less into the food of plants, have been detected in the field, drains, and other currents from cultivated soils. There is, however, no satisfactory evidence that land is impoverished by irrigation, though the consistence of the soil may be sometimes affected injuriously. The increase of the natural humidity of the soil provokes the growth of aquatic weeds, and in all freely irrigated lands the borders of the channels of distribution are fringed with water-plants, in spite of all efforts to destroy them. In many localities irrigation can not be carried on upon a great scale without the construction of large reservoirs. The objections to these arise from the fact that it is almost impossible to make the retaining dams or walls sufficiently secure to prevent the waters from ultimately bursting their barriers and overwhelming the country below with ruinous desolation. Works of hydraulics are full of examples of such calamities.

THE NEED OF CARE AND CAUTION.

The quality of the grain roots and other vegetables cultivated by irrigation is a point of importance, and Mr. Marsh says he has not found the meal of Indian corn or other cereals produced by irrigation less sweet or less nutritious than that produced on unwatered fields. There are, he says, economical obstacles to irrigation, as it is seldom practicable without considerable outlay. Dams, dikes, artesian boring machines, pumping-machines, reservoirs, aqueducts, and canals are some of them indispensable where irrigation is employed at all extensively. The ground must be prepared to permit either a flow over it or its gradual absorption and infiltration, and a good deal of labor is required in the way of grading before irrigation can be practiced with advantage. On the Alps irrigation is practiced almost up to the limit of perpetual frost. The water of the melting snows at its low temperature is conducted immediately over the grass. There is danger, too, of entering into the system without previous careful inquiry as to the sufficiency of supply, and this involves experiments varied and long continued to determine. There is another suggestion to make in estimating the economical value of irrigation—namely, that in some parts of our own country production is now overabundant, and needs repression rather than enlargement. Mr. Marsh says: "From all this it will be obvious that considerable evils attend the practice of field irrigation, and they would be sensibly felt in its introduction in a country which stands in no special need of such a resource for increasing its agricultural production." The object of Mr. Marsh in pointing out these evils has been to inculcate the necessity of caution in attempting a revolution in our agricultural methods, but by no means to discourage careful study of the subject, or judicious experiment in appropriate localities.

He points out the necessity of taking especial care that water shall not be allowed to stagnate and poison the air. Hilly and winding slopes admit of a simple and efficient mode of irrigation, or a substitute which is not available on level soil. This method has been practiced with success in many parts of the United States, where it is known by the name of "circling." It consists in horizontally terracing the slopes, or furrowing them with the hill-side plow, and leaving the surface permanently in this condition.

The duties of the general and local governments of the United States in this branch of rural economy are by no means confined to the simple protection of nature's waters from private encroachment. Governments ought to take steps for collecting and diffusing all knowledge on the subject, and by encouraging and aiding experiments and by

special inquiry into the physical conditions and capabilities, the wants and the means of all our territory. Much of the practical information needed may be gathered from European experience and by the study of the methods employed in those exceptional parts of our territory where irrigation has been long practiced.

Mr. Marsh, speaking of the stupendous net-work of canals lately constructed by the British Government in India, says:

> There are serious objections to the assumption of such burdens and responsibilities by republican government, but there are insuperable objections to any other system. The literature of European legislation, customary law, and judicial action on this subject is voluminous enough to form a library of itself, and of late years much has been done to lighten the labors of research on water questions, and to facilitate the application of law by codification and completion of digests and compends by private jurists.

Mr. Marsh says he is thoroughly convinced, after much observation and inquiry, that irrigation may be immensely extended among us with great commercial advantage, and that by reasonable prudence, and, above all, by a sufficient exercise of moral courage by our rulers, nearly all the evils which ordinarily attend the practice may be avoided or at least greatly mitigated.

On this subject the International Encyclopedia says:

> The ancient works for irrigation were stupendous. The canal of the Pharaohs, which connected Pelusuim with the Red Sea, was an irrigating canal. There existed a work in Arabia long before the time of Solomon, which in some respects excelled all works of the kind, modern or ancient, and corresponds well with the fact that the Arabians of that time were among the first mathematicians. In Yemen, Arabia, there was an immense reservoir for holding water for irrigating the valley of Mareb. The reservior was made by a dam 2 miles long and 120 feet high. It was constructed of immense blocks of ashlar, and was so durable as to serve the purpose for which it was built more than two thousand years. It then gave way, scattering ruin in the course of the torrent which it let loose.
>
> It must be borne in mind that one of the best examples in modern engineering is a dam in France across the Furens which is 164 feet high but only 328 feet wide at the top. This work almost sinks into insignificance when compared to the ancient Arabian dam.
>
> The plains of Assyria and Babylonia were intersected with a system of canals both for irrigation and navigation. In many of them water was raised by mechanical means somewhat like that practiced at present in Egypt.
>
> The ancient Peruvians and Mexicans constructed immense aqueducts for irrigation purposes whose existing remains, now partially used, astonish the traveler. The same may be said of China.

THE WATER LAWS OF OLDER LANDS.

Rome, it may be said, once ruled all the countries of southern Europe, northern Africa, and western Asia, where irrigation had its birth and its greatest development in ancient times. Like air, water was regarded as a necessity to human life, of which every one might use so much as was requisite for personal requirements, but which was not capable of appropriation to private ownership farther than in this sufficient quantity. Streams, rivers, ponds, etc., which were not in private ownership were regarded as things which belonged to the people as a nation. The roads and rivers were specially counted as public things by the Romans. The codes authorized the use of the rivers as shipways, or for fishing, but the ownership itself was vested in the state. They were not the property of the ruling sovereign, but of the sovereign power of the people collectively, each one of whom could use them as his own, but might not injure, neither segregate any portion or constituent part of them for his own. And this right was extended to all, whether Roman citizens or not, who were at peace with Rome.

Public rivers are defined to be such as were perennial or ever flowing, but if located through private lands were not the property of the

public unless navigable or capable of being made so by improvement, or from some other cause of public importance. A river was distinguished from other streams by its greater volume or more considerable local importance.

The bank of a river commenced at the limit of the spread of the waters at high tide, but when lands were not inundated, land below that line was property in public or private ownership. In the case of navigable rivers, and all streams which were public property, the beds belonged to the state. Should the waters leave the channel and take another, the river was considered to have moved, and the old bed became the property of those whose lands were taken for the new channel, while lands taken for this new channel became part of the public property—the river. In the case of non-navigable rivers and streams not regarded as public, situated on private property, the beds belonged to the riparian proprietors. While the beds were covered with water the rights of the proprietors were suspended, but revived when the waters receded. The banks of the public river might belong to the riparian proprietor to the extent that he had the right to take the fruits, cut the bushes, and fell the trees which grew thereon, but not so as to prejudice the use of the river or its banks by the public.

The public had a right to the use of the banks of navigable rivers, so that a qualified ownership of the soil of such banks was all that could be acquired by private persons. The owner of lands which were bounded by a ditch or wall following near the bank, or by a public road on the bank of a public stream, was not a riparian proprietor; to be such, his lands had to be bounded by the stream itself. Roman law made a marked distinction between rivers and other streams and the waters thereof. A river-bed and the water was each regarded as a public thing, the property of the state, necessarily excluded from private ownership, control, barter, or sale; the use of both was to be enjoyed by all.

The water of the river was the property of the people in common, and each, if the enjoyment of the public property would not be impaired, might divert a portion of the water from its natural channel for other purposes than those of his own domestic necessities.

The state was guardian of the common property, the water, and no person could use more than sufficient for his individual necessities and those of his family and cattle without a special permit. In the case of water sources and water-courses which were susceptible of private ownership, the right to use their waters for purposes other than the supply of the immediate animal necessities pertained primarily to the owners.

Springs and brooks being situated on private lands constituted parts of such property, but the water itself while running in its natural channel was the property of all the people. The banks and channels of public rivers were specially guarded from injury; the construction of works or the placing of obstructions, by the effects of which the current might be made more or less rapid, was forbidden. The construction of works upon the bank or in the channel of a public river, whether navigable or not, whereby either the high or low water flow would be affected, was also forbidden, and works which might have an effect such as described, erected without authority, were removed or abolished at the expense of the constructor.

It was declared lawful, however, for ripaiian proprietors, or those who lived near the bank of the public river, to erect works for the protection of a bank, provided that navigation was in no way impeded thereby, and that the river or the other bank was not injured. If damage resulted from any such work an official examination was made,

and the works were removed or ordered changed, and security for ten years was exacted from their owner or constructor. There was a provision concerning the protection of river banks, whereby it was lawful for riparian proprietors to construct works for the repair or protection of the bank adjacent to their property.

If damage was threatened by such works to the lands of another, a writ of inquiry was ordered, and security was exacted for ten years against the results of such possible damage.

The diversion of water, whether of floods or low-water flow, from public rivers, reservoirs, or tanks, without the sanction of a special privilege in each case, was prohibited.

The water privileges were of two kinds: First, those granted to individuals, of water for use on individual lands; second, those affecting water for public use. When a joint right to divert was issued to several persons, the division of the water was left to those holding the right. The use to which water was to be put was not always stipulated in grants, provided that it was to be used in good faith and not wasted. The user of water was liable for damages "by reason of anything done, dug, sown, delved, or built, whereby the river was corrupted." It was declared that water privileges should be "exercised in such a manner as not to damage other persons having similar rights."

Immemorial possession and use of running water by a private individual, as for the operation of a mill or in irrigation, gave prescriptive rights to the continued enjoyment of such use.

No possessor of water, though having held it from time immemorial, had the right to use it wastefully to the prejudice of others.

Springs on private lands were the property of the land-owner, on the principle that to such proprietor belonged all above and all below the land and all it produced. The right to use spring water might be acquired by others by agreement or prescription.

Spring waters flowing off, joining with other waters, and forming brooks on other lands, became common property, but their use was dedicated to the owners of the lands along their course, so that such waters for purposes of diversion belonged to these riparian proprietors.

Water rising out of the ground on a private estate, as being a part of the spring, was the property of the owner of the land; but when any portion of such water had escaped from the tract where it came to the surface, it became a common property of all the people. But so long as it remained in channels on private estates only the owners of the banks of its channels could divert it from its course and use it, except this right should have been acquired as a servitude.

But even these bank proprietors could not divert such waters if in so doing other proprietors were injured.

Water drawn from its source or diverted or drawn from its course into an artificial and private channel, or when stored in a reservoir or tank, itself in private ownership, became private property.

The user might do with it as he chose, providing his use was in good faith—not wasteful. The rights to draw water from a private spring or stream by others than its owners, and to conduct waters across lands owned by others, ranked as servitudes. A predial servitude under Roman law was a definite right of enjoyment in some particular respect of one person's property by the owner of other adjoining or neighboring property. Such a servitude could be held only as an appurtenance to land owned, being called predial because it could not exist without an estate.

The right of passage across the lands of another and the right of conducting water through such lands appear to have been recognized as

indisputable privileges from the earliest times of the Roman jurisprudence.

The right of way to construct a canal or other conduit through the property of another, and to lead the waters through it, was one of the chief rural servitudes. The right to take water through the property of another in a ditch or other conduit could be acquired by prescription use for a long period of years, or by agreement, or, in the case of public works, title to the land necessary could be acquired by expropriation and payment therefor. When acquired as a title, of course the right was complete. When as a servitude, the right was accorded for a certain purpose only. A right to draw and use water from another's spring or rivulet might be imposed by agreement or prescription as a servitude thereon.

MODERN ITALY.

"In northern Italy the waters of all streams, whether navigable or non-navigable, appertain to the royal or public domain." The old established claim of the cities, communes, and associations of proprietors and of noble individuals in Lombardy to the supplies of water which they had for long periods of time actually utilized, having been recognized, the Government asserted and maintained its ownership to all natural streams, whether navigable or not.

Diversions of water under the old claims were subjected to Government regulations, but when the Government had come into control of the streams, so many claims had grown up that the proprietorship of the state was almost a barren one.

In Piedmont the right of property in all running water was reserved to the state. This reservation applied not merely to the large class o rivers, but also to the streams and torrents, the water of which could only be used under specific grants from the Government. After all Italy had been brought under one Government there was promulgated in 1865 the code of Victor Emanuel, of which article 427 is as follows:

> The national roads, the shore of the sea, the harbors, bays, coasts, rivers, and torrents, the gates, the walls, the ditches, the bastions of forts and fortifications form a part of the public domain.

This provision of the code of 1865 is the law now in force in Italy, and under it all running waters, except those of very small streams, are claimed as property of the Government, representing the people as a nation; and they are administered very much as are the waters of the navigable streams of France.

Navigability itself was a ruling consideration in France, while a volume of water for irrigation was the point of importance which made the stream one of public utility in northern Italy. As a matter of fact, in northern Italy every stream of perennial volume, other than very small streamlets, is regarded as a river; and every stream of intermittent flow from the rain-fall or melting of snows, except the smallest, is regarded as a torrent.

The principle that ownership of the land carries with it all beneath its surface and all it produces has prevailed from the times of the earliest recorded laws in all the north of Italy. Waters rising out of the soil have always been regarded as the absolute property of the owner of the soil so long as he retained them within the bounds of his estate and did not permit his title to suffer abridgment by allowing some other proprietor to acquire a prescriptive right to the use of the waters. The springs always remain the property of the owner of the soil, but the right to use their waters may be wholly alienated and held by the owner of some other property. The principle as to ownership of a spring is the same

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in all Italy as it was for Piedmont and other parts of the Sardinian Kingdom.

As the law now stands in all Italy, the owner of one or both banks of a little stream may use its waters in irrigating his riparian lands, but he must restore the drainage and residue of it to the ordinary channel; while he who is not a riparian proprietor can not take such waters at all without the consent of all the riparian proprietors; nor can any one riparian proprietor assign his right to water from such a stream to any one else.

The riparian right to divert waters from a stream is confined to the case of very small streams, and is scarcely known in the valley of the Po. During the times of the ownership of the streams and waters by the sovereigns of the states, and by the petty feudal rulers, and by the sovereign power of the states, as the representatives of all the people in each case, the right to divert water from any river or torrent could only be acquired in the states of northern Italy by special grant or concession of privilege made on a formal application, after due examination and consideration of all the interests to be affected. And now that the country is united under one government, and the waters belong to the royal or public domain, the same rule, and substantially the same formalities in applying it, exist.

It appears that the policy of the rulers in Lombardy, until the later years of its existence as a separate state, has generally been either to dispose of the waters of its streams in absolute property by gift or sale to those who constructed the canals to lead them out, or itself to construct such canals and sell the waters directly, or indirectly through farmers of the canal revenues, to the irrigators. The Government of Piedmont has generally been more conservative in the care of its waters. Absolute grants of ownership of waters ceased in that country before the beginning of the present century. Water privileges for all time have been issued, but the full right of regulation was reserved to the Government, and the cession of proprietorship in the water was expressly disclaimed. There are, however, important works whose proprietors have absolute rights of ownership in the waters, acquired in the centuries gone by. During the later years of the existence of the Piedmontese Government its waters were disposed of only on long-term leases. This last-mentioned policy is that pursued by the Government of Italy since it has supplanted those of Lombardy and Piedmont, the duration and terms of concession being similar to those of France.

FRANCE.

While under the dominion of Rome all matters pertaining to the streams and waters of the country now called France were subject to Roman law. Long before the close of the Roman rule the people had the full protection due citizens of Rome, so that at the time of the conquest of Gaul by the Visigoths (A. D. 470 to 480) there was much land held in individual ownership, with the consequent private rights, on small streams; but under the Merovingian kings the freehold titles to land disappeared, property was held by a different tenure under the sovereigns, and all rights of ownership in water-courses and waters was vested in the rulers themselves. The feudal system then grew up, and the water-courses, from having belonged to the nation and the people, or to private individuals, under Roman law, and then exclusively to kings under Merovingian rule, became dependencies upon the liefs of the feudal courts, who assumed almost complete ownership of and con-

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trol over them. A struggle was ever present between these nobles and the kings for the control of the water-courses, and the conflict did not cease until the Government had become centralized and feudalism overthrown, during the fourteenth century. In that century the study of the Roman law was actively reviewed in France, and feudalism being on the decline, the Roman law recognizing ownership of streams not of public importance, non-navigable streams, by the riparian proprietors became incorporated into the law of France.

The kings asserted their ownership of all navigable streams and left the control and virtual ownership of non-navigable ones to the bank-owners, but really without any formal laws upon which to ground their claim of title to them. The public possessions of the kings held for the benefit of the nation became known as the "public domain." This policy of holding fast to all the nation's property is still adhered to by the Government, so that water-courses and waters once declared navigable and raftable can never be alienated from the public domain and become in any sense private property.

The changes in the form of government occurring a little less than a century ago appear to have resulted in no completed action affecting the laws or customs respecting waters until 1803–'04, when the Code Napoleon, which is the present civil code of the country, was promulgated. The only direct statement relating to the ownership of water-courses or waters in this code is as follows: Highways, roads, and streets at the national charge, rivers and streams which will carry floats, shores, ebb and flow of sea (the land newly made by the sea), ports, harbors, roadsteads, and generally all portions of the national territory, which are not susceptible of private proprietorship, are considered as dependencies on the "public domain." A royal ordinance of 1835 enumerated all the streams and parts of streams in France deemed navigable and claimed as of the public domain, and other ordinances of later dates have added to the list.

The sovereign authority to declare streams navigable, and hence part of the public domain, has not been disputed, but riparian proprietors who have been dispossessed of their right to water for irrigation, by the exercise of this power, have claimed and been allowed indemnities for actual damage caused them. Although only certain streams and parts of streams have thus far been added to the public domain, the administration may at any time declare other streams or parts navigable or raftable, and thus make them public property, afterwards paying the riparian proprietors for actual damage. The state owning these water-courses is, of course, owner of the waters forming them, and these, with the beds, are alienable from the public domain; their use only can be granted. According to the terms of the civil code, water-courses not navigable are common property. If the ownership of non-navigable waterc-ourses can not be fixed elsewhere, then these streams belong to the nation, just as well as do those which have become part of the public domain.

Riparian proprietors claim the ownership of the channel bed to the center line in front of their property, and the claim is allowed, when the beds are permanently laid dry from any cause; alluvial deposits along their banks accrue to the benefit of the land-owner adjacent to whose field they form; islands forming in the channels belong to the adjacent bank owners, and prior to the passage of a law specially to the point in 1847 the owner of one bank, although he might have secured administrative authority to build a dam in front of his own property, could not carry it past the center of the stream, or connect it with the opposite bank, without the consent of the bank owner. Until very recent years

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the beds of streams of this class belonged to and were under control of riparian proprietors, except where the Government has exercised a supervision of works and channels to insure a free flow for flood waters.

The waters of non-navigable and non-raftable streams were formerly claimed as the private property of the riparian proprietors. Their origin and division and the necessarily common control of the streams upset this theory. Then they were claimed by these proprietors as a sort of property held in common by them for the exclusive benefit of their lands and industries. It was and is still claimed by the owners of lands not bordering the streams that the waters belong to the whole people of France; and while the riparian proprietors are given a right to use them in irrigation and otherwise, it is not exclusive, but the Government can grant concessions for the use of some part of them on lands not riparian, so long as rights already accrued by use be not unduly or injuriously limited or their exercise inconvenienced by such action. The riparian proprietors now say, if the waters belong to the nation, they, the bank owners, have a special and complete servitude on all such waters, which right to use is continuous and not forfeitable by failure to avail themselves of it at any time or any length of time, except as between themselves. The fact of the ownership of the waters of non-navigable and non-raftable streams by the nation is now pretty well settled, and the tendency of decisions is towards a declaration of ownership by the nation of the beds also so long as occupied by the waters—so long as they are courses for public waters.

Starting several centuries ago with almost complete ownership and control of the waters and channels of the streams not navigable nor raftable the riparian land owners have since been restricted in their rights, and now find themselves without any recognized claim of ownership in the waters, and only a semblance in the channel beds, until after these shall have been laid dry, but with a preferred privilege to the use of the waters.

We find irrigation constantly favored in the laws in preference to manufacturing and many other uses of waters, domestic necessities and navigation alone ranking it in the scale, and the first of these two uses being the only one decidedly preferred to it in the administration of the laws.

On non-navigable and non-raftable streams the administration in the theory interferes with private operations conducted by those who as bank owners have rights on the streams under the ancient usages and civil code to regulate works in the channels or on the banks with a view to preserving the channels in the interest of the public and for developing a free passage for flood waters, and with the view of preserving the interests of navigation on the main stream below.

On the water-courses of the public domain the policy of the Government is actuated by a solicitude for the interests of navigation, and then by an almost equal interest in promoting the economical and full use of the waters in agriculture, manufacturing, and industrial pursuits generally, and finally by a realization of the pressing necessity for promoting the arterial drainage of the country, in order that floods may be prevented and valuable lands reclaimed.

On non-navigable water-courses the administration is not authorized to interfere between the owners of works already constructed and those proposed or newly constructed. The administration is bound to presume that the proprietor of lands on streams has a right to water therefrom, and can only interfere to the extent of regulating his works. The engineers can advise the parties in interest and bring before them

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all the facts as to measure of water supply and extent of use, etc., but if on such showings agreements can not be arrived at, the administration has no alternative but to sanction the construction of any new work proposed, provided the work itself is unobjectionable, leaving the court to decide whether or not the new appropriator is entitled to water. On navigable streams the administration is invested with full powers, not only to regulate works of all kinds, but to consider all questions relating to water privileges. In case of both classes of streams the engineers are charged with the duty of collecting and arranging data respecting the supply and use of waters.

The construction and management of all public works except those specially confided to the minister of war, of the navy, of education, of posts and telegraphs, and some others are delegated to the secretary of state or minister of public works. The care of all waters and water-courses, whether of public domain or not, their control and the control of the acts of individuals on their banks, are regarded as of public concern, and the administration thus has to do with all affairs affecting streams. It is now the intention of the Government that all water-courses of public importance in France, whether navigable or raftable, and consequently of the public domain, or not floatable even for rafts and timber, but which are of public utility, shall be subject to the supervising care of special agents of the Government called guards. On non-navigable streams the guards are generally appointed on recommendation of the riparian owners, and others interested.

No work of any kind, sort, or description may be erected upon a navigable stream or river floatable for rafts, or timber, or upon any stream so declared, nor can any water be taken from such streams, except it be taken in a bucket or other similar hand vessel, without the project for which it is required and the plan by which it is to be constructed, if a work, or used, if a water privilege, having been first submitted to the administrative authority and publicly made known, so that it may be opposed, if necessary. Older rights and those of industries most needful are always protected in the administration of affairs from day to day; but no right is so old or use so pressing that its owners have the power to control the diversion of the people's water, or use it in a wasteful manner, or in any way hinder the full development and prosperity of other institutions dependent on water supply.

It is on rivers and portions of rivers where it has become necessary to construct dams for navigation, and those still higher, which have been dammed for purposes of flotation, that water privileges are chiefly sought after for power purposes, irrigation, municipal supply, and industrial use. Such water-courses are public property, under full control of the administration. Non-navigable tributaries of navigable streams, and these streams themselves above the points where they become navigable, are also under the control of the administration. Still or stagnant waters, those draining from marshes and ditches, that have free communication from navigable or raftable streams, and whose waters flow the year round, or waters where ferry-boats can enter at all times, and those cared for at the expense of the state, make part of the public domain, and a right to dispose of or use them may be had only by special authorization.

Projects requiring special privileges to use water or sanction of plans to erect works in water-courses are undertaken either as private enterprises of individuals to water their own lands, to run their own mills, or for other private purposes, or as speculative enterprises by individuals, associated landholders, or capitalized incorporated companies

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desiring to sell water to consumers. When water privileges or permits to construct works are desired by individuals, for their own private benefit, in the use of water or otherwise, on navigable streams, an application must be made to the prefect of the department where the intended work or diversion is to be made.

When water privileges on streams navigable and of the public domain are desired by individuals, companies, or societies, for speculative purposes, all permits or concessions have to be acquired by decree deliberated upon in the council of state. Whenever possible, the diversion of water for an irrigation canal or other use (requiring the construction of a dam in the river) is effected by a work which serves at the same time to hold back water for the promotion of navigation. Works designed for taking water for any purpose of a holder of a water privilege are always constructed and maintained at his expense, and when in close connection with a dam for navigation purposes, are carried out by the administration. Upon non-navigable water-courses which have not been declared to be dependencies on the public domain, in the civic code, and which have not been improved in the interest of navigation, the expense of cleaning and caring for the channel generally is borne by the riparian land owners.

Works erected and acts committed in the channels or on the banks of non-navigable or non-raftable water-courses, when they present no obstruction to free flood flow, are subject to regulation by the law as administered by the courts; but works located upon navigable streams, when not duly authorized by the administration, constitute infringements of the authority of the commission of public ways, and are subject to repression. Water-privilege rents for irrigation works are rated upon the basis of the increase in yield due to irrigation, and are fixed at a sum annually paid, equivalent to one-tenth of the increase in value of produce on the land irrigated over its produce before irrigation.

Without meaning to limit the duration of water concessions, the rents are revised every thirty years, for, though revokable at any time, water-right concessions on public streams are given for an indefinite time. Water privilege heads held in private control previous to the edict of 1566 declaring the inalienability of the public domain are free from the charge of rents, as are also those whose holders have titles derived by purchase from the Government.

The exclusive right to water for milling and irrigation purposes from streams too small to be regarded by the kings as of public importance were accorded to the owners of the bank lands, apparently on the ground that they owned the beds and waters as well as the banks, previous to the time of the Code Napoleon. In later years it appears to have become recognized that the waters were in reality a common property, and that the bank proprietors had only a right to use them and not a right of ownership in them.

Still there was the open question, to whom were the waters a common property; the riparian proprietors claiming to be the owners in common of the waters of each stream, and submitting to the control of the streams by the Government only as it was based upon the general police authority of the nation; while the Government asserted its right to control, not only because of its general police powers, but because of the fact that the waters were really common property of the whole people, and not of the riparian proprietors alone, and that public interests were to be promoted, as well as other private interests guarded by it, and that its mission was one to promote public utility as well as re-

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press or prevent abuse of private privileges in the protection of other privileges.

The continued and growing abuse of the riparian water-right privilege brought about an increased necessity for upholding this latter view, so that it became a popular sentiment, and owners of lands not riparian to the streams asserted a right to the waters for their irrigation on the ground that such waters were a common property of all the people; and asserting that the riparian owner's privilege of using them was not an exclusive privilege, but that upon a grant or permit from Government any land owner could divert them for use on his lands. In this view of the case by far the greater number of land proprietors were interested, so that the governmental policy of control was strongly upheld. Now the manufacturing interests took alarm. The owners of the hundreds of mills and manufactories depending upon water supply for power and other purposes scattered along the streams all over France, and holding rights, many of them dating back in the times of the counts, and all valuing the riparian right as a protection to their water supply, were arrayed against the advancing theory of the waters belonging to all the people and due to all the people for use. The Government continued to uphold the theory of the waters of these small streams being a common property of all the people, but no step was taken to accord land owners other than riparian proprietors any right to use them.

The case appears to have stood this way when the Code Napoleon was promulgated in 1804. This code contained provisions which in course of time were recognized as placing the ownership of the waters of the smaller class of streams in the nation, but declared the use of things of this class to be common to all. Left with this provision only, the waters of these streams would have been thrown open to use by all the people. But an article, under the head of "servitudes," seemed to place a special servitude (right of use) on these waters for the benefit of riparian estates. The Government had its hands strengthened in its policy of control and regulation, and the fundamental principle contended for by the owners of lands not riparian, as well as by Government, was recognized.

The ownership of water belongs to the State, without prejudicing the right to the same which corporations or individuals may have acquired by legal title in conformity with the provisions of special laws in relation to public real estate. The enjoyment of the ownership of water is subject to the following provision: No one may use the water of the rivers in such a manner as to obstruct navigation, nor construct in them works which hinder the free passage of vessels or rafts, or the using of any other means of water transportation. In a similar manner the hindrance or obstruction of the use of the banks is prohibited when they may be necessary for the same ends.

The proprietor of water, whatever may be his title, has no power to hinder the use of so much as is necessary for the supply of persons or stockmen who are in possession of or living on real estate; nor to oppose the indispensable works to provide for that necessity in such a manner as shall be the least burdensome to the proprietor. He may have the right to indemnity reserved, except from those inhabitants who have acquired the use of water by prescription or by other legal title.

The provisions of this code relating to the servitudes of water shall not interfere in any manner with rights legally acquired up to this date concerning the same.

The proprietor of water has no power to divert its course in such a manner as to cause damage to a third party from overflow or from any

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other cause. If any person dig a well on his premises, notwithstanding he may diminish the flow of water upon the adjoining land, he is not obliged to give indemnity. Every one who has acquired water, the use of which he may dispose of, has the right to pass through the intervening lands, subject to the obligation of indemnity to their owners, and also to the owners of any lower lands upon which the water may leak or descend; but edifices, their courts, gardens, and other appurtenances are excepted from the servitude established by the foregoing provisions. He who has the right of use has the right of way for water, and is obliged to construct the necessary channel through the intermediate lands, although there may be other channels for the use of other waters. He who has on his lands a channel for the use of water which belongs to him may prevent the opening of another, offering to give passage through his own channel, provided it does not cause damage to the claimant. He must permit the passage of waters across canals and aqueducts in the manner most suitable to the course of the waters which are to be conducted by them, and the volume must not be altered nor the two waters mingled in both aqueducts.

In the case of right of passage through intermediate lands, if it becomes necessary to conduct the aqueduct over a road, river, or public stream, it is indispensable that permission should be previously obtained from the authority to whose care the road, river, or stream is intrusted. Such authority shall only grant permission, subject to regulations binding the owner of the water for which passage is sought, not to hinder the passage of the water nor injure the highway, nor interfere with or stop the course of the river or torrent. He who without previous permission makes a passage for water or causes it to flow upon the highway shall be obliged to restore it to its former condition, and give indemnity to any one to whom damage may have been caused, in addition to paying the penalties imposed by the public regulations.

He who seeks to use the privilege (right of way through intermediate lands) must previously, first, prove that he can dispose of the water which he claims to conduct; second, affirm that the route which is solicited is the most suitable and the least burdensome to third parties; third, pay the value of the land which he shall occupy by the canal according to the estimate made by experts, with an addition of 10 per cent.; fourth, compensate for all immediate damages, including those which will result from dividing the land into two or more parts.

Where the use of a canal already built is offered, he who claims the passage of water must pay in proportion to the quantity of the same and the value of the land occupied by it and the necessary expenses for the preservation of the canal, without prejudice to the indemnity that must be given for any other expenses which may be occasioned by the passage which is to be conceded.

The quantity of water which may be passed through the aqueduct established on the adjoining land shall have no other limitation than that which results from the capacity of the water-way as determined by its dimensions. Should the person enjoying the use of the water-way be compelled to enlarge it, he must bear the necessary cost, and pay for the land which is merely occupied, and for any damages caused. The damage is to be estimated by experts with an addition of 10 per cent., and account shall be taken of both immediate and resulting damages. The legal servitude before mentioned carries with it, subject to provisions hereinafter contained, the right of way for persons and animals and the transportation of the necessary materials for the use and repair of the water-way.

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The provisions and same laws concerning the passage of water are applicable to marsh lands requiring drainage or an outlet. The concessions which may be obtained from the competent authority are to be without prejudice to other rights previously acquired. Every one who has the use of an aqueduct, whether it passes through his land or through lands adjoining, must construct and maintain the bridges, canals, aqueducts, subterranean and other necessary works, so that the rights of others may not be prejudiced. Those desiring to enjoy the use shall pay in proportion to that enjoyment, if there be no prescription or contract to the contrary. The code contains provisions for keeping the water pure and for the construction of such works as may be required, in order that the course of the water may not be interrupted.

The owner of land subject to the servitude of right of way may designate the place in which the servitude shall be constituted.

If the proper judge shall decide the place to be impracticable or very burdensome, the owner of the land must designate another. If the place is subject to the same objection as the first, the judge shall designate one which shall be established, taking into consideration the interest of both properties.

If there are several pieces of property through which must be given a passage or a public way, the servitude shall be that of the shortest distance. If the distance shall be the same upon the properties, the judge shall designate through which of them it shall be given passage.

The width of the right of way shall be such as the necessities of the case may be deemed, in the discretion of the judge, to require, but shall not exceed 5 meters nor be less than 2 meters, without the consent of the parties interested.

The court of cassation and the council of state have each decided also that the fall or slope of a channel is not the property of the land proprietors, and that it enters into the class of things which, by the terms of an article in the Code Napoleon, do not belong to anybody, the use being common to all, and the enjoyment regulated by the police laws; hence the administration grants a proprietor the right to back water into the channel in front of lands above him by means of his dam, so long as he does not injure or endanger the lands in any way. Here, again, was a step towards the abolition of the exclusive riparian control of the smaller stream, and a movement towards declaration of public ownership of the channels themselves. And thus the matter stands. The riparian proprietors still monopolize the right to use the waters from streams of this class. The code merely gives every riparian owner a privilege of using the water. No matter how old a privilege may be, the administration in the public interest has always the right to turn sufficient water past the dam to satisfy the personal wants of proprietors below, and it can even compel the construction of a sluice-way in the dam to be used for this purpose.

As a matter of fact, the streams are controlled and the waters apportioned out of those who have claims on them by administrative regulations. The matter of the ownership of springs has been one full of contention in France; but it is now well settled by the provisions of the code and the decisions under it. He who possesses a spring within his field may make use of it at his pleasure. The code defines certain circumstances under which the control of springs is limited and qualified, the causes being the necessities of communities for water for domestic purposes, the necessities of the state for water for purposes of navigation, the rights which persons other than the owners of springs may have acquired by purchase or by prescription. The courts can, in the

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interests of agriculture in general and for the benefit of local agriculturists, prevent wasteful or selfish use of spring waters.

The ownership and control of springs is so complete and absolute that so long as the waters remain within the property where they rise, even though used as a power for manufacturing purposes or otherwise, the administration can do nothing to interfere with the proprietor's use of them.

But if spring waters be led across or into property other than that containing the source, for whatever purpose, the stream is subject to regulations, as in the case of others. The owner of a spring can not change the course of its waters when they furnish the necessary supply to the inhabitants of a commune, village, or hamlet.

Government can take possession of springs to feed canals for navigation, but on condition that it pay a just indemnity.

The absolute right of ownership in a spring is also modified by purchased titles, by prescription, and by servitude set up by the division of an estate containing a spring.

SPAIN.

The Spanish law of waters, as it now exists, is a code in itself, which was finally determined and promulgated in 1866, after a study of the whole subject for eight years by a commissioner appointed for the purpose. The law of 1866 comprehends all that is treated in laws of various kinds relating at all to waters, high seas, sea-shores, beaches, bays, rivers, etc. The Spanish law makes the broad distinction between waters on private and corporate property, which it calls private waters, and those on the public domain, which are called public waters.

With respect to the acquirement of right to divert water for irrigation from streams on private or corporate property the law may be summarized as follows: Waters which rise on private property belong to the owner of the property, provided he does not forfeit his right by nonuse for twenty years.

Waters running through private property are private waters, subject to use by owners of the banks. They may appropriate them for the purpose of irrigation on their estates, to be taken in their order from the head of the stream down.

Works for the diversion of waters from a private stream may be constructed by the owner of the banks without official sanction, provided always that the amount of water to be diverted does not exceed 10 liters (about one-third of a cubic foot per second) in any one instance; but, if the proposed diversion exceeds this amount, notice must be given through the alcalde for the information of the governor of the province.

This notice is given for the purpose of setting before the people the facts in the case, and in order that an investigation may be held, which will determine whether or not the proposed appropriation will interfere with existing rights.

The waters of public streams are held to be the property of the kingdom. It is necessary to obtain an official sanction or grant of right before such waters can be diverted and used in public or private irrigation enterprise, except where the quantity diverted by any one appropriator does not exceed 10 liters per second, or where it is to be abstracted from navigable rivers by pumping machinery, or when the water appropriated is only the rain or storm water which drains rapidly away in the torrent beds. This grant of right is accorded only after ex-

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tended and minute examination of the proposed project by the provincial authorities, and after hearing all that may be said by those whose interests may be opposed to the diversion. There is no such thing as unlicensed appropriation in large amounts, and no such thing as unregulated diversion of waters from the streams.

The waters are held by the Government for the use of the people. Under the Spanish law water is diverted for irrigation in large volumes from the public streams, but it is done under special sanctions from the authorities of the district, in a manner not to interfere with or injure other persons dependent upon its use.

MEXICO.

The problems of rain-fall, water supply, and irrigation are of primary importance in the Republic of Mexico. A study of the laws and systems pursued therein is of the greatest importance to American engineers and agriculturists engaged in the practical work of irrigation. Mexico is essentially a dry country; its cultivation is dependent on artificial distribution of water. Its indigenous vegetation presents all the characteristics of an arid region. From all historical evidences it is seen that irrigation was among its earliest necessities and was the most prominent care of its people, of whatever race or condition. The soil of Mexico, as well as of that portion of the United States which formerly belonged to our neighboring Republic, is fertile and fruitful when once vitalized by the application of water. The table lands are everywhere adapted for grazing, and water can generally be found in quantity sufficient for the use of cattle. The forests are valuable and abundant. That an increase in water-storage capacity would largely add to the agricultural value of Mexico is obvious, and such an increase is becoming especially necessary in connection with the construction and maintenance of railroads.

The sources from which the water supply is derived along the line of the Mexican Central are springs, wells, storage reservoir, and permanent streams, and these are all dependent upon the annual rain-fall. In most cases the supply of water at our water stations is obtained from wells dug by the company, and these vary in depth from 20 to 300 feet, and the water is raised to the tanks either by hand or steam pump. In a few cases they have springs that afford a gravity supply, but they are very few. In order to preserve the rain-fall, storage reservoirs have been built, from which the water is distributed by open canals or ditches, and in many places extensive aqueducts of masonry have been constructed to convey the water across valleys so as to utilize it for irrigation. This system of irrigation, by means of storage reservoirs, can to good advantage be greatly increased, as where land can be irrigated two crops a year are obtained; but at the present only a small portion of the rain-fall is utilized. The season known as the rainy season lasts some two months, and is for the most part confined to the period between June 15 and September 15. The following will show you the average amount of rain-fall at the City of Mexico for seven years and the State of Aguas Calientes for fifteen years:

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Months.	City of Mexico.			State of Aguas Calientes, fifteen years.		
	Total number rainy days in seven years.	Average number rainy days.	Average quantity.	Total number rainy days in fifteen years.	Average days.	Average quantity.
			Inches.			*Inches.*
January	16	2	0.2	35	2	.38
February	15	2	0.1	25	2	.29
March	32	5	0.4	27	2	.17
April	40	6	0.3	8	1	.05
May	94	14	2.6	78	5	.74
June	136	19	3.9	162	11	3.62
July	167	24	4.5	216	14	3.89
August	149	22	5.7	219	15	4.66
September	115	16	3.8	173	12	3.84
October	76	11	1.1	99	6	1.29
November	32	5	.4	42	3	.34
December	15	2	.2	35	2	.43
	887	128	23.2	1,119	75	19.70

The only artesian wells on the line of this road are at the City of Mexico, where good water is found at the depth of from 200 to 500 feet below the surface. These wells are usually flowing, but with only a small head, and have to be pumped when a large supply is needed.

The laws and customs controlling water in Mexico, so far as the road is affected, require the provision of suitable passages for all water used for irrigation.

On February 14, 1856, a law was enacted controlling the distribution of water. The old unit of measure for water was the surco (or sulco) in the country, and the paja in cities, but an act of March 15, 1857, put the French metrical system in force in the Republic, and a decree of August 2, 1863, made the liter (0.26417 gallon)* the unit of measure for water, fixing upon 6½ liters per second of time as the equivalent of a surco (or sulco), and forty-five one hundredths of a liter per minute as the equivalent of a paja of the old measurement. In cases of legal contest, wherein a right to a certain quantity of water was claimed under prior titles, or documents, sanctioned by law, the measurement was still to be given in surcos.

Engineers and surveyors were required to have regard, whether in city or in country, to the degree of inclination (amount of fall) in water channels, to take into account in each case the amount of pressure, and to present in their statements both the formulas employed and the reasons for their calculations.

The royal instruction of October 15, 1754, was passed to regulate the sale and distribution of land and water rights in the Indies. Subdelegates were to be appointed by the viceroys and presidents of the royal audiency, who were to have jurisdiction of such matters, and they were directed not to disturb possessions in lands embraced in settlements, or on which labor had been expended, or which were cultivated or utilized for pasturage. It was also required that all persons who desired to possess royal grants of unoccupied lands and water, and

* The metric system is founded upon the meter (about 39.37 inches), which was intended to be the ten-millionth part of the distance from the equator to the pole, measured over the surface of the earth, but in reality differs slightly from this measurement. The liter is a cubic decimeter, the decimeter being the tenth part of a meter. The unit for land measure is the are, which is a square having sides of 10 meters in length. The hectare (100 ares) is about 2.471 acres.

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those owners who had possessed, without occupation or cultivation from the year 1700 up to the date of the instruction, should present themselves before the subdelegates and prove their titles within a period of time to be designated by the same authority; and when they had titles to allege which were not yet confirmed, but were issued before the year 1700, they were to be allowed pacific possession in conformity with the law. They were, however, required to register the title. From those who had no title there was required a sworn declaration of long possession, which was allowed to stand as a just title by prescription. Those who desired to acquire title were required to expend labor upon, cultivate, or occupy the grants for a period of three months; and if the period expired without the requirements having been fulfilled by the grantee, the grant might be denounced by any one who fulfilled them.

It was also provided that possessors of lands sold or distributed in or after the year 1700 should never be molested, and their titles were thus confirmed; but those who did not possess their property as aforesaid were required to solicit confirmation of their titles from the audiencias of their district or from the proper authorities, and if they failed to do so within the period designated their possessions were forfeited to the crown, although labor might have been expended on them.

The guiding and fundamental principle throughout the whole of the regulations will be found to have been that all such property was annexed to or incorporated into the royal crown to such a degree that in order to hold possession it was necessary that individual possessors must have alleged and proved that their water rights had been conceded by special favor, because the law declares that to the prince, and to no other, appertained the right of distribution of water. This is still the controlling principle of Mexican law.* The waters must remain under the sole and absolute dominion of the sovereign, all waters of the public rivers (or water-courses of public and common use) being his rights. This principle was so far qualified that any one might take what he needed for domestic use, but no one could take public waters upon his private grounds for irrigation without royal permission. A torrent is a stream of water originating from snow and rain at certain seasons, that is, when the snow and rain raise the streams. Rivers are divided into public and private. The public river is one where all enjoy the right to fish. The private stream is one by which some contract or agreement has become private property, and differs in nothing from other private property, and in describing it "it has no banks." Banks are the precise limits between which the streams run in their natural course, which are as the shores to the sea. In concession of land, if concessions are made jointly of the waters originating upon it, they are appurtenances of the lands granted. Being a servitude, waters had their place among the royal country servitudes. Fountains and springs belong to the owners of the lands in which they rise as parts and appurtenances thereof, for which reason they are conceded with the lands.

A servitude is the right of doing something on the land of another, or of preventing the owner from doing something.

The servitude is a property appertaining to the thing, so that it adheres to it, no matter who may be the owner. Servitudes depend on the proximity of two predial estates, that of the person entitled to the servitude, and that of the person who has to submit to it. If for the enjoyment of the servitude the estate on which it is imposed requires

* The rights of the prince descending to the Government of the Republic.

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some repairs, they must be done by him entitled to the servitude. The right of servitude is not susceptible of division, but its enjoyment may be limited to days, months, etc. Such rights are acquired in the same manner as other property, and are either continued or interrupted. Continued servitudes are those which may be used daily; interrupted ones, such as can not be so used.

In connection with the use of water there are both urban and predial servitudes.

The predial servitudes relating to water are, first, the right of conducting water by means of canals or pipes over the land of your neighbor for the purpose of driving a mill, or of irrigating your land; second, the right of drinking out of a fountain, or of watering there your cattle.

The servitude of the aqueduct is the right of conducting water upon the ground or field away from the stream for irrigation or other use, specified in the right of servitude, which carries with it the right of way for the water-pipes, etc., and for those who have the care of them.

It is unlawful to construct any work damaging others. If the construction of any work on the banks of a stream causes damage to the lands of a neighbor, the law gives him a right of action for the damage occasioned, and the works constructed must be removed.

He who alleges his servitude is obliged to prove it; possession is not sufficient. The right must be acquired in one of three ways: by agreement, by inheritance, or by prescription. It is unlawful to alter the natural course of a stream to the prejudice of third parties; but a person through whose ground the water is conducted may alter the channel for the sake of its more convenient use upon his land, provided that other parties be not prejudiced thereby.

A servitude may be constituted not only at the source of the water, but upon any part of its course. It may be for a continuous flow, or a flow at certain intervals of time—that is, stated days or hours. The examination of springs must be made by experts, whose report must state under oath that the truth has been faithfully given, without favor toward either of the parties.

The measurements for distribution are regularly obtained from the examinations, or measurements to determine the amount of the natural flow, the distribution being made to each person according to his position on a line. Hence, in measurements of examination, no changes are made, whereas in those for distribution the water-ways are enlarged, diminished, and changed to conform to the letter of the grants of water. Measurements of examination are to be conducted at the most favorable distance from the reservoir or ditch, so that the water may run as nearly direct as possible and without too great rapidity of current. The reservoir shall be made in conformity with some geometrical figure by which its area can be calculated, to which shall be applied a marking-board in such a manner as to show the quantity of water that is withdrawn. The marking-board shall have marginal numbers showing the available height of the water, so that by multiplying this by the width the area of the vertical section may be formed. It is to be understood that water must always be taken in the manner in which it has been from the beginning, so that no more can be taken, nor can it be taken by any longer route. Those who are in possession of a water servitude must be maintained and protected. In order to constitute such a servitude the flow of water must either be continuous or at certain intervals of time.

Dominion can not be exercisd upon the lands of another unless distributing tanks or aqueducts are built with separate basins, with aper-

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tures in the sides, having gates of the proper size to give to each the quantity to which he is entitled. If the form given to the aperture is that of a square, the area being given, the square root shall be the diameter of the orifice. If it should be circular, the diameter may be found by the rule of Archimedes, that as 11 is to 14, so is the area of the figure to the square of the diameter, the square root of which is the diameter of the required orifice.

In distributing water from basins or reservoirs all the parties interested must obtain their amounts from apertures at an equal depth, although the sizes of the openings may be different. In taking water from a horizontal canal, through orifices in its vertical sides, a stop of the same size and figure as the opening must be set into the wall on the side of the opening towards which the current runs, so as to drive the water into the orifices.

When various parties participate in the distribution of water, all tanks and receptacles and all openings for drawing it off should remain unchanged in their dimensions and proportions, so as to preserve to each the quantity publicly granted. The builder of such tanks and orifices shall be the judge of the shape most suitable, but they shall have a uniform altitude, increasing or diminishing the bases, if rectangular, but if circular their centers must be on the same horizontal line. It is an inflexible rule that the water which issues from those apertures should have the same fall, for two reasons—they start from the same level line of base; or, if they take water from a fall, it is from the same apron-stone upon which the waters fall, although carried away from thence in different troughs or chutes. The gravitation of water increases its velocity in proportion to the distance through which it falls. The point of delivery must be below that of the source. The surface of the water curves to correspond with the surface of the terrestrial globe, and in using a level, to avoid the error of assuming the water-level to be a straight line, the instrument should be set in the middle of each stretch of the line to be leveled, which may be longer or shorter according to the slope of the ground. All the proprietors who participate in the benefit derived from the works which have been treated of are under obligation to contribute to the payment of the expense of their execution in proportion to their interest, according to an appraisement by experts. Those who by their own culpable negligence have occasioned any damage must be responsible for it.

The owner of land in which there is a natural fountain or source, or who has dug a running well, may cover it, or confine it by a pond or dam, to detain its running waters for his own ground, and may use and dispose of the waters freely. If he have surface waters which pass upon another piece of land, the owner of such land, upon the lapse of twenty years, reckoned from the date on which he has constructed works designed to regulate their fall or course, may acquire property in the waters so received. But this provision does not prohibit the owner of the source of any water, or of a pool, or a dam, from availing himself of all of the enjoyment of the waters possible within the limits of his estate.

The lower lands must receive the waters which naturally, and without the work of man, come from the upper or higher lands, as well as the stone and earth which it takes in its course, nor shall the owner of the lower land make any works which obstruct the servitude, nor the upper any works that increase the servitude. The owner of the land on which there are works to conserve the water, or on which for an alteration of the water-course it becomes necessary to construct new ones,

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is required, in the absence of any special law to the contrary, either to make necessary repairs or constructions, or without demanding remuneration to allow the same to be made by land owners who have experienced, or are immediately exposed to injury from the water which he has arrested in its flow, or diverted from its natural course. The provisions of the foregoing are applicable to the case in which it is necessary to relieve any land of those materials which accumulate or hinder the flow of water, resulting in damage or peril to a third party.

In distributing water among a number of claimants the following allowances are made: For a flour-mill, 8 continuous sulcos; for a pulling mill, 3 sulcos; for sugar-mills, 8 sulcos; and to irrigate a tract of land of about 33⅓ acres, 2 sulcos, or if it be a cane plantation of the same size, 4 sulcos. The quantity is, however, not absolute, but depends on the slope of the ground and other circumstances.

When the water supply is found insufficient to meet the requirements of the parties interested, resort must be had to distribution by turns, some using water in the day-time and others at night, or any other way which may be agreed upon, because that which belongs to the whole public should be so controlled that all may have a share in the distribution.

LOWER CALIFORNIA.

The sub-prefect of the northern part of Lower California, reporting on the water supplies of that district, mentions the Colorado as the only important river in the district, and refers to information in regard to that stream already in possession of the Mexican Government. After enumerating various smaller streams and a few ponds and lagoons, which furnish drinking places for cattle, he says:

None of the waters to which I have referred are used for agricultural purposes, because the small grains—oats, wheat, and barley—which are cultivated in this district belong to the temperate zone and are grown in winter. Corn, beans, and other products of this nature are planted only in damp soil, which does not need irrigation.

DURANGO.

The political chief of Oro, in the State of Durango, writes to the secretary of state of that commonwealth that in the district under his authority there are thirteen hot springs, some of which are used to good advantage in the irrigation of gardens. The rivers which fertilize a large part of the district are the Ramos and the Sestin, which unite to form the Nazas. The Sestin, from the neighborhood of Cerro Prieta to its confluence with the Ramos, has a length of about 60 leagues (156 miles), its greatest breadth being about 328 feet, and its general depth about 5 feet. The Ramos has a length of about 31 miles, with an extreme breadth of about 260 feet and an average depth of somewhat over 3 feet. The waters of these streams, whose volume may be estimated at about 25 cubic meters (882 cubic feet), are utilized in agriculture with very good results, wheat and maize being the favorite crops, and yielding the best returns when the precipitation of the rainy season is largest. Besides these rivers there are many small streams which, without being permanent throughout the year, afford sufficient water to make them useful in the irrigation of gardens. There are some unimportant ponds in the district, but no lakes or lagoons.

A law passed by the legislature of Durango, and dated November 11, 1881, contains substantially the following provisions:

No one is allowed to construct on the rivers or other waters belonging to the public, or along their banks, any new works, or to alter ex-

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isting ones in such a manner as to change the direction, height, breadth, or depth of the dams, dikes, or aqueducts, without previous license from the public authorities.

Any person desiring such a license is required to state in writing to the proper local authority the kind of work which he proposes to execute, the materials of which it is to be constructed, its dimensions, and other necessary particulars, and the place where it is to be made.

The authority receiving application for license to construct works on the public waters or their aqueducts will note in writing the day and the hour in which it was presented, and will give the desired record of it. The same authority will publish the petition by posters in the locality in which the petitioner resides or by newspaper if there is one. A copy thereof will be furnished to the corporation attorney, so that within eight days the latter may give his opinion whether the proposed work will or will not be prejudicial to the public interests. This opinion will then be sent with the petition itself to the State government. The opinion of the attorney will be accompanied by that of an expert consulted by him, whose fees will be paid by the petitioner.

The petition, having been received by the State government, will be published in the next three issues of the official journal. If during its publication, or within eight days thereafter, no opposition is made to the proposed work, and if no objection shall have been set forth in the opinion of the corporation attorney, the State government will authorize the execution of the work, and will cause copies of all records in the case to be sent to the party interested, for whom they shall serve as evidence of title. The same should also be inscribed in the public register of property.

Any one desiring to oppose the execution of a work must present himself in writing to the state government within the period indicated in the last paragraph. On receiving such notice of opposition the government shall immediately have it sent, with a record of all its antecedents, to the judge having primary jurisdiction in the locality to which the proposed work appertains, in order that he may decide whether or not he ought to prevent its execution on account of its being in conflict with some acquired right, or causing, either to the public or to the individual opposing it, detriment for which indemnity can not be obtained.

If the damage which the work would cause is such as can be indemnified, the judge shall cite the person proposing to construct the work and the person opposing it to a verbal conference, to the end that they may mutually agree on the indemnity to be paid.

Whenever it shall appear that the opposition to a work is unfounded, the person making the opposition shall pay the costs of the proceedings thereby necessitated; and if there shall also appear to be rashness or malice in the opposition its author shall indemnify the party opposed for all the damages suffered through the delay in carrying out the work.

The amount of indemnity having been fixed, the work shall not commence until it is paid.

Judicial proceedings arising under this act will be in summary form, as provided by the code of civil procedure.

A decree having been pronounced, the records received from the State government must be returned, and with them must be sent an attested statement of the action of the local tribunal.

Changing the course of a river or other stream of public use, or draining off its waters by means of works constructed in it or on its banks, is absolutely forbidden.

In cases of urgent necessity, to prevent inundation, the destruction

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of embankments, reservoirs, or aqueducts, or other damages equally serious, permission may be granted for the construction of such works as the authorities may deem necessary. But if any work constructed under such circumstances would interfere with other works previously existing, it can not remain longer than the circumstances continue which render it necessary, unless permission be obtained under the provisions of this act, and such permission shall be applied for within three days after that of the local authorities is solicited. The latter authorities are required to apprise the State government of their action in cases of the class to which this paragraph refers.

The preceding provisions do not apply to the partial or total reconstruction of works already existing, or which have been executed according to this law, and which are not to be changed in their direction, height, breadth, and depth. A person having occasion to make partial or total reconstruction of any work conformably to this paragraph must notify the local authorities, so that they may assure themselves that the work proposed is really one of repair or reconstruction.

So far as they are not in conflict with the present law, the provisions of the civil code and code of procedure relative to the use of public waters, or to servitudes or works connected therewith, are left in force.

This law was promulgated on the 10th of November, 1881.

JALISCO.

The principal rivers which traverse this State are the Cuitzeo (sometimes called the Tololotlan) of Santiago, or Grande, the Verde, the Juchipila, the Lerma, the Zula, or Atotonilco, the Ayuquila, the Tuxpan, the Chacala, the Ameca, the Bolaños, the Apazalco, the San Pedro, the Acaponeta, the Cañas, and the Camotlan, most of which are also known under other names. The largest of these streams is the Cuitzeo, which rises in the town of that name, and after a course of 98 leagues (255 miles) enters the ocean to the northwest of San Blas. Its average flow is about 111 cubic meters (3,920 cubic feet) of water per second, and its use in irrigation, which is now small, might be largely increased. Opposite the town of Juanacatlan there is a cataract about 65½ feet in height, which would furnish power to the amount of about 30,000 horse-power, of which only the amount required for one flour-mill is now utilized. There are many points along this river, or near it, where hydraulic wheels after Poncelet's system could be advantageously used.

The Verde which rises in the State of Zacatecas, is a tributary of the Cuitzeo, and for a distance of 47 leagues (122 miles) its course lies within the State of Jalisco. Its waters, which have a flow of 50 cubic meters (1,766 cubic feet) per second, are utilized in irrigation to some extent, and by means of lateral canals they might be largely employed in working hydraulic motors.

The Juchipila, another tributary of the Cuitzeo, rises in Zacatecas, and its course lies within the State of Jalisco for only 17 leagues (about 44 miles). It has an average flow of 16 cubic meters (565 cubic feet) per second, and is utilized in irrigation.

The Lerma, which rises in the Almoloya region of the State of Mexico and empties into Lake Chapala al Oriente, flows through Jalisco only 12 leagues (about 29 miles). It has an average flow of 80 cubic meters (2,825 cubic feet) per second, but is available for irrigation only when its waters are high. This stream presents more advantages in the States of Michoacan and Guanajuato than in Jalisco.

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The Zula rises within the State, and has a course of 30 leagues (78 miles) before emptying into the Cuitzeo. It has a flow of 8 cubic meters (282 cubic feet) per second, and its waters are employed on a small scale in irrigation.

The Ayuquila rises within the State, and after a course of 70 leagues (182 miles) empties directly into the Pacific. It has a rapid current throughout almost its whole length, and although it has an average flow of 30 cubic meters (1,059 cubic feet) per second, it serves to irrigate only small areas.

The Tuxpan rises within the State and empties into the Pacific, receiving in its course of 60 leagues (156 miles) the waters of numerous tributaries which rise in the spurs of the volcano of Colima. It is somewhat rapid and has an average flow of 28 cubic meters (989 cubic feet) per second. Its waters are employed to some extent in irrigation, but not so much in this State as in Colima.

The Ameca rises within the State, has a length of more than 55 leagues (143 miles), and empties into the bay of Banderas, on the Pacific coast. It is a fine stream, having an average flow of 20 cubic meters (706 cubic feet) per second, and is capable of being utilized in agriculture.

The Bolaños rises within the State, and after a course of about 48 leagues (125 miles) empties into the Cuitzeo. It has a rapid current, with an average flow of 15 cubic meters (530 cubic feet) per second. It is utilized in agriculture.

Several other streams, with volumes ranging from 2 to 10 meters (71 to 353 cubic feet) per second, are more or less used in agriculture; but the principal use both of these and those designated by name above is in stock-raising. There are also innumerable small streams, tributaries of the larger ones.

The most noteworthy lakes in this State are those of Chapala, Magdalena, Mexcaltitan, Atemanica, Cajititlan, San Marcos, Zacoalco, Atoyac, Sayula, Zapotlan, and Santa Maria del Oro, besides which there are many others, which, although smaller and not so well known, are nevertheless of great utility.

Lake Chapala is 90 kilometers (56 miles) long, and has an average width of about 17 kilometers (about 10½ miles). It is the most important lake in the State, whether considered with reference to the facilities it affords for internal navigation or to its utility in agriculture and stock-raising to the people along its shores; and by means of canals, especially one connecting it with the Ameca River, its waters might be more extensively utilized for both of these purposes. The other lakes mentioned are much smaller than Lake Chapala. With the exception of Lakes San Marcos, Zocoalco, Atoyac and Sayula, they all have potable waters; and the same is true of the numerous smaller ones not mentioned by name.

There are few permanent irrigation works in the State, mere temporary appliances being generally used to draw off the water for irrigation or for live-stock. The works at Bellavista, executed with great skill by Señor D. Gabriel Castaños, should, however, be mentioned as a noteworthy exception to this rule.

In the municipality of Atemajac de las Tablas (in the district of the same name) there are four reservoirs, but their chief use is the storage of water power for flouring and saw mills. In the municipality of Tescuitatlan there is a public reservoir known as the Santa Rosa, in which rain-water is stored. Its length is 502 meters and its breadth 260. In the municipality of Tizapan el Alto there is one reservoir—

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that of Las Cuartas—in which enough water is stored for the irrigation of a small area on one ranch.

Reports are published from many other municipalities, and numerous small streams and springs are referred to as furnishing water for the irrigation of orchards, gardens, or fields. The aggregate area fertilized by their water is quite large, but there are scarcely any among them that have a volume of more than 1 or 2 cubic meters per second, and no important works are reported for making an increased area available to irrigation.

MICHOACAN.

The principal streams which lie wholly or partly within the limits of the State are the Lerma, the Balsas, the Marques, the Tepalcatepec, the Duero, the Astula, the Apisa, the Rio Grande de Morelia, and the Huetamo.

The Lerma is provided with dams and reservoirs to facilitate irrigation, and several towns or villages and forty farms along that part of the river embraced within the limits of Michoacan avail themselves of its waters to irrigate wheat, maize, chick-peas, etc. In the Duero and the Morelia there are some small dams. The other streams are turned to little account partly because of the broken character of the districts through which they run, and partly because of the limited extent to which agriculture in those districts is carried on. The volume of water in these streams is very large. The Balsas, for example, empties into the sea with a volume of 132 *bueyes*, 12 *surcos* of water;* and the Marques at a point called the Juntas, before receiving its last tributaries, has a flow of 44 *bueyes*. In the southern districts of the State irrigation is used in the cultivation of sugar-cane, indigo, and rice, each estate having one source or more from which a supply of water is obtained. The water is conveyed to the fields in covered conduits.

The population is generally located near the streams, and there are but few who have occasion to resort to wells. Such wells as there are range from 10 to 20 *varas*† in depth in the case of the deep ones, while the others range from 2 to 10 *varas*.

It is worthy of remark that in the higher and colder parts of the State the springs and fountains are permanent throughout the year and maintain a medium temperature throughout the day. In the hot part of the State the streams are more numerous, but many of them run dry in October, and do not flow again until the end of May. The chief cause of their disappearance is readily found in the rapid evaporation which occurs in such hot climates. According to observations made at Churumuco in May, 1883, a cubic meter of water exposed to a dry, hot atmosphere, the temperature being about 100° Fahr., lost by evaporation 2 to 2½ liters per hour, while observations made at Lake Sirahuen, with a temperature of about 59°, showed a loss of hardly one-fourth of a liter in the same time.

The stream known in different parts of its course as the "Caramecuara," "Las Joyas," and "San Juan" is used for the irrigation of 20 *caballerias*‡ of land belonging to the different estates through which

*The *buey* is a somewhat indefinite expression, meaning a stream of water as large as the body of an ox, while the *surco* is the quantity conveyed in a furrow made for the purpose in irrigating land. Some years after the adoption of the metric system a decree was issued making 6½ liters (a little less than 1.72 gallons) per second the equivalent of the *surco*.

†The *vara* is a measure of about 2 feet 9 inches in length.

‡A *caballeria* = about 107 acres.

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it flows before uniting with the Tacàmbaro; while the latter, which has a volume of 3 *bueyes* in the dry season and an average of 8 *bueyes* during the rainy one, irrigates 6 *caballerias* of farming land, as well as the fields and kitchen gardens near the city of Tacàmbaro. The Turivan has an average volume of 4 *bueyes* through the dry season, and in its whole course through the district irrigates 12 *caballerias* of land. The Puruaran, or Caliente, has a volume of 5 *bueyes* and 4 *surcos* from November to June, and from June to November its flow is considerably augmented by the rains. It irrigates about 7 *caballerias*. These four streams, with fourteen smaller ones, none of which irrigate more than a few hundred acres of land, have an aggregate volume of about 26 *bueyes* of water, and serve for the irrigation of an aggregate area of 55 *caballerias* (5,585 acres) of land. A small addition should be made to this total for areas irrigated from springs, ponds, and swamps.

MORELOS.

In the district of Coatlan there are three rivers—the Amacusac, the Chalma, and the Tambembe. The Amacusac is formed by the union of the San Geronimo and the Chontalcuatlan, their confluence being a short distance outside of the district. The waters of the San Geronimo are utilized for irrigation on many wheat farms in the district of Villa Guerrero, or Tecualoya. During the rainy season it has a flow of about 35 cubic meters (1,236 cubic feet). The Chontalcuatlan, which receives a number of tributaries, furnishes water-power to many small factories, and its waters are utilized to some extent in mining. After watering innumerable orchards and gardens along its banks it still has a flow of 25 cubic meters (883 cubic feet) in the wet season, and from 10 to 12 cubic meters (353 to 424 cubic feet) in periods of drought. The Amacusac, formed by the union of the two rivers last named, has a flow of 60 cubic meters (2,119 cubic feet) during the rainy season, without including freshets, and in time of drought it has somewhat less than half that volume. Thus far but little use has been made of its waters in irrigation except for the orchards immediately along its banks. After receiving the waters of several tributatries this river takes the name of Rio Grande, and still lower, after passing beyond the limits of Morelos and uniting with the Pueblo, it is known as the Mezcala or Balsas until it reaches the sea at Zacatula.

The Chalma is the most important river in the district, not in respect to size, but on account of the fertility which it confers on the many towns and districts through which it flows. It rises in the State of Mexico, rapidly increasing in size as it receives the waters of numerous springs and rivulets, and becoming a considerable stream before entering Morelos. It waters extensive tracts of level lands in the vicinity of the sugar mills of Cocoyotla, Actopan, Santa Cruz, San Gabriel, and the estate of Cuachichinola, and at the same time irrigates the fields in the towns of Coatlan del Rio, Tetecala, Mazatepec, San Miguel Cuantla, Cuachichinola, and Puente de Ixtla. It has a flow of 25 or 30 cubic meters (883 to 1,059 cubic feet) during the rainy season, and 10 to 12 cubic meters (353 to 423 cubic feet) during the dry months.

The Tembembe is scarcely utilized at all in irrigation. Its flow during the wet season equals and often exceeds that of the Chalma, but during the rainless months it runs almost dry.

There is only one dam in the district of Coatlan del Rio. This was constructed in the Tembembe River, at a cost of about $20,000, for the irrigation of the extensive fields of the Miacatlan estate; and it also serves to supply the town of the same name with water. It is con-

sidered a meritorious piece of work in respect to its architecture, its extent, and its solid construction. The district being well supplied with water, there are no reservoirs for its storage.

The laws which govern the distribution of water are understood by the writer of the report to be those comprised in the civil code of the federal district and of the Territory of Lower California, this code being in force in Morelos.

OAXACA.

District of Cuicatlan.—A river known as the Rio Grande, which empties into the Papaloapam, flows through this district and furnishes water for irrigation at many points along its course. Its volume in the rainy season amounts to 200 cubic meters per second, or more; but during the dry months it falls to four or five meters. Of its smaller tributaries there are many which dry up during the latter portion of the year, but it also receives a considerable number of permanent streams, most of which are more or less utilized in the irrigation of maize, sugar-cane, or other crops.

District of Tiaxiaco.—Many small streams are enumerated, giving their source, direction, estimated volume, etc., the latter in most cases falling below one cubic meter per second during the dry season. Most of these streams are utilized to some extent in the irrigation of crops, besides furnishing water-power for mills. There are no large rivers in the district.

District of Yautepec.—The most important stream within its limits is the Rio Grande de Tehuantepec, which rises in the mountains of Quiechapa and Mixtepequez, and empties into the Pacific 10 or 12 miles from Tehuantepec. The average flow at the lowest estimate is about 5 *bueyes* per second. It is utilized in irrigating sugar-cane and maize at certain points along its course. There are also several smaller streams which are turned to account for the same purpose. Owing to the smallness of the rain-fall the streams in this district have greatly diminished in size, and there are no important bodies of water of any kind within its limits, nor have any laws been enacted on the subject of water distribution.

District of Ocampo.—The principal rivers which traverse this district are the Villa Alta and the Rio Mudo. The character of the country is not favorable to irrigation, and the streams which flow through it, though many of them are constant, are not turned to account for that purpose. The same remark will apply to the waters of a number of small lagoons found within its limits.

District of Choapam.—As regards rights to the use of water, the ancient Spanish ordinances in relation to lands and waters are in force.

District of Tuxtepec.—No irrigation is needed because of the abundant rain-fall. The provisions of the civil code of the federal district, amended in some few particulars, are legally in force under State authority, but in the absence of any need for the appropriation of water difficulties in regard to water rights seldom arise.

District of Juchitan.—There is scarcely any irrigation practiced. The Astula, which is the principal river in the district, has a volume of 8 cubic meters during the dry season, and its plains are referred to as "wide and fertile."

District of Teposcolula.—Reports from a number of municipalities mention irrigation as practiced on a small scale within their limits. The mayor or president of each municipality annually appoints an officer, whose duty it is to distribute the waters in fair proportion among those having fields or gardens to irrigate.

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QUERETARO.

In the neighborhood of Juriquilla there are four small and unimportant reservoirs; one party is constructing one which will contain 1,100,000 cubic meters of water, and will command a large part of the valley of Queretaro. On an estate to the north of Juriquilla there are two good reservoirs, but they are dependent on the rains for their supply of water, and have only been filled six times in the last twenty-seven years. The largest one, known as the Santa Catarina, is 2,500 meters * long by 900 wide and 6 deep. The other, known as the Pinto, is 1,275 meters long by 600 wide and 4 deep. A reservoir of small size is found on the San Miguelito estate, northwest of Juriquilla. It is of little importance, but serves to irrigate some limited areas of tilled land.

There are many permanent streams whose waters are used in irrigation, but none having a volume of more than a few cubic meters. There are also a number of small lakes and lagoons and some important springs in the State.

There has been no State legislation especially bearing on the use of water, which is regulated by the civil code, the Spanish laws, and the ancient ordinances of land and water, according to their respective dates.

TAMAULIPAS.

The situation of this State in the northeastern part of the Republic, with the Gulf of Mexico bordering it on the east, renders it comparatively independent of any artificial means of supplying the crops with water.

A report to the State government from the council of Nuevo Laredo mentions the Rio Bravo as the only source of water for live-stock in the dry season. During the rainy season it is subject to heavy floods, and overflows the bottom lands along its banks, on which the farmers raise sure and abundant crops.

TLAXCALA.

The Zahuapan and the Attoyac are the only streams deserving the name of rivers. The former, which is tributary to the latter, is utilized between the town of Apetatitlan and its confluence with the Atoyac, by eleven estates, six towns, and a number of small farms, while it also furnishes water-power to several mills and factories. It is, however, but a small stream, its volume during the dry season not exceeding $1\frac{1}{2}$ cubic meters per second, after receiving the waters of many springs and rills.

There is no place of any considerable population on the Atoyac, but it furnishes water for the irrigation of ten estates and the supply of six towns. In the rainy season it is a roaring torrent, swollen by the waters which pour into it from the mountains, but during the dry weather it dwindles to a volume of about 4 cubic meters per second.

In the eastern part of the State reservoirs are used for the storage of rain-water, that being the only means by which a reliable supply for man and animals can be secured. These reservoirs vary in size according to the needs of the localities where they are situated.

There has been no legislation in this State to regulate the appropriation of water for irrigation or motive power. The proprietors of land and manufacturing establishments use the waters of the rivers in ac-

* The meter=39.37 inches.

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cordance with the privileges conceded by the colonial government in the original titles to their property; and those who do not enjoy such rights have recourse to the authorities of the municipality controlling the water which they desire to use, and are allowed to take the water needed for irrigation subject to an annual tax, which goes into the municipal treasury.

VERA CRUZ.

The water courses are not utilized in agriculture or in manufactures. In the former no machinery is used, nor is there any resort to irrigation, and when there is a prolonged drought the consequences are severely felt, the agriculturists making no efforts to utilize the waters that are at hand, but contenting themselves with the hope of rain while their crops perish.

Legislation on the subject of water is only rudimentary.

The principal rivers of the district are the St. Peter and St. Paul (one river) and the Cazones, both of which are navigable for short distances. No estimate is given as to their volume and no information as to irrigation, either on these streams or their tributaries, within the district.

A return from the district of Acayrican enumerates many small streams, including a number of arroyos which disappear during the dry season, but no mention is made of any use of these waters for irrigation.

A report from Orizaba enumerates various streams, some of which are used to a small extent in irrigation; but the largest (the Ingenio) has a flow of only 5½ cubic meters, while some of the others dwindle during the dry season to less than 1 meter.

From a list of the principal rivers which rise and flow through the State of Vera Cruz, those having a length of 40 leagues (104 miles) or upwards are presented below:

Panuco, Tamesi, Moctezuma, Calabozo or San Juan, De los Hules, San Pedro, San Marcos or Cazones, Tecolutla or S. Pedro and S. Pablo, Mautla or Rio Frio, Papaloapam or Quiotepec, Tesechoacan, Zapotla or San Juan, Blanco, Coatzacoalcos.

ZACATECAS.

In the municipality of San Alto mention is made of two streams and a number of springs which are used to a considerable extent in irrigation. The larger stream has a course of 6 leagues (about 16 miles) and a volume of 30 *surcos*. As regards water rights, the rule is that the different landed proprietors "take what water they need where their property is crossed by a stream, leaving the rest for others." There is some irrigation from small streams in other municipalities heard from.

In Nochistlan there are a few unimportant rivers and two small reservoirs which serve to irrigate small areas of land. At Juchipila there is a stream from which considerable water is obtained for the irrigation of orchards and gardens along its course, the quantity being increased at one point by a reservoir wherein water is saved for use during the dry season.

AUSTRALIAN IRRIGATION LEGISLATION.

The colonial governments of New South Wales and Victoria joined in a conference to examine the Murray River drainage basin, in order to arrange the terms on which this boundary area could be regulated. To some considerable extent it represents the problems involved in the

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flow and distribution of the interstate waters within our arid region. The legal control of the Murray, banks and basin, seems unquestionably to rest with the Colony of New South Wales, whose bondary line it is, but the larger considerations of physical geography, topography, hydrography, and climate forced a consideration of the interests of Victoria. It was finally proposed and decided upon that a joint trust be formed with these powers:

(1) After defining the areas, it was recommended that said joint trust "shall have power to regulate all diversions of water from the river and its tributaries."

(2) That certain tributaries may be regarded as feeders to the main or "Murray" river, or, as the term is, "compensation water." Other tributaries "may be diverted and used by the respective colonies through which they flow."

(3) The whole waters of the upper and lower rivers (Murray) are "deemed to be the common property of the" two colonies interested. Each colony in general to have the right to one-half the said waters, subject to reservation of "compensation water" aforesaid.

(4) "That all natural diversions" shall "be gauged" under the trust. The portions of such diversions not returned to main river channels "shall be debited" to the colony "diverting the same."

(5) That the trust "fix and determine" the "high-flood levels," and have control of all waters flowing above them, using them as may be deemed expedient.

(6) That all expenses be jointly borne, and that as far as possible united action be had in the construction of works.

The balance of provisions provide for the organization, etc., of said trust, its members and officers.

AN AUSTRALIAN REPORT ON AMERICAN IRRIGATION.

The following extended series of extracts are from a report on American irrigation to the governor of the Australian colony of Victoria, made by the Hon. Alfred Deakin, M. P., chairman of the royal commission on water supply, 1884–'85. They will be of great interest to the American reader, not only because of the author's lucid style, but because his field of investigation covers in a remarkable manner the lines of inquiry followed in collecting the materials for the first edition of this report, while he presents in much detail precisely the kind of information which it has been the object of the Department to collect:

EXTENT OF AMERICAN IRRIGATION.

The extent of the area irrigated in the West is the more surprising since the practice as compared with that of Europe is a thing of yesterday. In Mexico irrigation was practiced before the Spanish conquest, and there are a few spots in its old provinces, now forming the southwestern States of the Union, where, either at the Indian villages or at the missions, plots can be seen which have been cultivated for a century by its means. In Utah Americans began irrigating in a primitive way forty years ago, and their example was followed in that fashion, especially near the Mexican border and under Mexican tutelage, for a score of years. But the real development of American irrigation, now so wide-spread, has taken place entirely during the last quarter of a century, and mainly during the last fifteen years. During that period it has been lifted out of its early rudeness and carelessness into something like science and skill. Its traditions date no farther than this; its records do not date so far. The strides it has taken may be judged from the now current estimate that, as against 4,500 miles of canal in Lombardy, there are 12,000 miles of main canals in the West, and that the capital invested in and about them is expressed in millions of pounds sterling.

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A VIVID DESCRIPTION OF ARIDITY.

The irrigated lands of America, though widely various, may be divided into two great classes. The rolling prairies of Kansas and sloping uplands of Colorado belong to one division. Poor and brown in ordinary seasons, their buffalo and bunch grasses are often green after favorable spring rains, and it seems but natural that, when a constant supply of water is secured, these treeless expanses should be gradually conquered by the march of settlement from thickly-inhabited and closely-cultivated districts. Not so with the sandy wastes stretching in a broad belt from the north to the south and southwest of the arid region. Here there is no prospect of any early invasion due to pressure of population or overflow from crowded towns. Here there is nothing to attract, and everything to repel. Here even the rich red mesa lands that lie under the shadow of the foot-hills are desolate at all times and all seasons—so desolate that it seems impossible they should ever sustain a living thing. From them the illimitable desert, bare and blinding in its glaring barrenness, stretches far away to the mirage towers that shift along a dull and undefined horizon. Much of the soil is so powdery, even in winter, that it follows in a lazy trail of cloud the horse of the solitary rider, or is sucked up in whirlwinds under the scorching summer sun. Elsewhere its gravelly and gritty surfaces, strewn with splintered bowlders, are seamed into gaping gulches and fissures of inappeasable thirst. There is no grass, the only vegetation being a withered-looking brush resembling salt-bush, the thirsty-looking cactus, a juiceless scrub like our ti-tree, or thorny variety of stunted palm.

Such is the Mapimi Desert in Mexico, the Maricopa Desert in Arizona, or the Mojave Desert in California; and such, without water, they must remain. As it is, these wastes of sandy aridity and gray innutritious herbage, surrendered by nature to solitude, surround oases created and sustained by irrigation. In the distance the track of a canal, pleasantly breaking the dull level of the dried-up plain, is marked sometimes for miles by a line of green bushes following its sinuous course. By and by this line broadens as if into a great green plantation, dotted with houses, divided into gardens, and decked with flowers. Its little fields, fringed with flourishing trees, are bright with fresh-springing pasture, upon which stock are gazing, or else crowded with dark orange groves and clustering vines. In the center of it is a tiny township, busy with teams and traders, where the train stops for a moment or two. When it starts again the houses and trees vanish as if by enchantment, and the engine rushes on through the dreary desert once more.

It is thus that the eye bears testimony to the fruits of irrigation in the South; and in the North, though in a less striking way, the lesson is the same. The unpretentious ditches that wind along the hill-sides or prairie ridges are not notable themselves until it is perceived that, where they are not, a scattered herd of rough cattle, a small party of roving Indians, or a burly rancher are the only objects of interest, while where they multiply are the buildings, the barns, and the business. A stretch of open country broken by long ridges of canals, its paddocks plotted off into little checks, with a barefooted Chinaman or high-booted European, spade in hand, directing the water from one to the other, are common features of the landscape, where one beholds industry and intelligence transmuting barren surfaces into orchards and fields of waving grain. Familiar, too, are the knots of active men, the little camp of tents, and toiling teams, that mark the progress of a new ditch into the wilderness, where it is to create a settlement and maintain it in the face of all seasons. The Indian village, the Mexican pueblo, the American township, all cluster about the natural stream, or the artificial stream which makes it serviceable; for in these parched regions its progress is everywhere a triumphal march. It is here veritably the water of life—life to the grass and flower, to the loaded tree, to man, and to the city of men, whose homesteads and harvests follow in its wake.

HOW THE WATER SUPPLY IS PROVIDED.

In western America the water supply is almost invariably provided by private companies. In one instance, that of Los Angeles, California, where this rule obtains, a water supply has been undertaken by the municipal body, but it is not employed for domestic purposes, being applied, curiously enough, to irrigation only. The outlay incurred is recouped by sale of the water to the farmers, a great number of whom have their plats within the city boundaries. The local governing body of Salt Lake, Utah, has also undertaken a similar work, though this is maintained out of the ordinary rates instead of by sale of water. Local governing bodies, however, do not, as a rule, go so far as this, even where, as in Los Angeles and Salt Lake, water for irrigation is as essential to the maintenance of towns as is water for drinking purposes. The utmost they do is to permit, as in Carson, City, Nev., a canal 6 feet wide to run along a main road unfenced, or, as in Phœnix, Ariz, to permit ditches 3 feet and 4 feet deep to cross their roads without requiring them to be fenced or bridged. Beyond

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this, municipalities do nothing. State governments have never done anything in the way of undertaking or assisting in the construction of irrigation works. They are not expected to undertake them, and there does not appear any likelihood of their ever having any proprietary connection with them. The Central (General) Government maintains if possible an attitude of even greater indifference. All the irrigation works of western America, with the exceptions above named, have been constructed and maintained wholly and solely by private persons. Not only has the Government spent nothing upon them, but it has known nothing of them. They have been constructed outside the law, extra legally, if not illegally. Even now only two States and one Territory have attempted to deal legislatively with any of the problems raised, and it is not claimed that in more than one of these has anything substantial been achieved. In Colorado the State engineer has issued one report, which includes a register of water-rights. In California the State engineer has issued one report specially dealing with irrigation, but there is no register of water-rights. In no other State or Territory is there either report or register. These reports are of great intrinsic merit, but have a further interest, inasmuch as they are the only official papers published by any State bearing upon irrigation.

DIFFICULTIES OF THE INQUIRY.

Only the fringe of the subject having been touched officially, the visitor who desires to study irrigation finds that the data upon which he must build his conclusions are not to be obtained ready garnered in a State office, but that they are virtually uncollected, and must be sought for in the fields of practical farmers. The officials of the Central Government and of the State governments exhibit the most considerate courtesy, but can only regret that they have been so hampered by want of means and authority that they have not been able to carry on their work in this direction, so as to place the matter upon a scientific basis. This condition of things is doubtless largely due to the newness of the country, and will tend to disappear as these regions attain to the age, population, and organization of the Eastern States. All that could be done to urge the legislature of California to action has been done by the State engineer, who, with his colleague in Colorado, has managed at last to partially educate public opinion as to the duty of the State in this relation. But their best endeavors at present can only point to the sources in which knowledge must be looked for. The farmers of America compare favorably with those of any country in method, quickness, and caution, but they are not given to recording exact quantities of water, or the special conditions of its use, or yet the results obtained with the exactness required for professional investigation. Many of them have been their own engineers or have employed engineers who either used no plans or have mislaid them. The many lawsuits as to the use of water now pending in California naturally render capitalists who have engaged in great irrigation enterprises within its boundaries somewhat chary of giving their private records for publication. Again, partly because of the neglect of the various States to collate facts and figures relating to irrigation, each district has grown up with its own theories, prejudices, and customs, differing often to a noteworthy degree from those of its neighbors.

DIFFERENT WORKS IN DIFFERENT STATES.

The circumstances of the several States also naturally lead to great differences in their irrigation works. The mountain torrents of Colorado require to be grappled with by large and powerful weirs before they can be raised, so as to cover the high rolling uplands, while the shallow rivers of Southern California call for light structures only capable of elevating water a few feet, so as to lead it across sandy plains. Farming in the bottom lands of Arizona has led to the use of wing-dams, which can direct the flood waters of spring along the ridges, and thence command the flats beneath, and a somewhat similar class serve for the low levees of Kansas, while its bench or mesa lands (the secondary flats or table-lands running up to foot-hills) call for larger ditches and stronger works, drawing their supply from the turbid Arkansas. In Utah and New Mexico we touch upon primitive works supplying small plats of land with little driplets of the precious fluid, out of which, with care and economy, thriving settlements are built up. The parent source of this system, and indeed of American irrigation, is Old Mexico, where irrigation, from the simplicity of the Egyptian water-lifter to the masonry weir and solid stone aqueduct of centuries ago, spreads its way over the whole of the territory closed in its temperate and tropic zones. If it is difficult to arrive at accurate information in the United States, in Mexico it is impossible. There is no trustworthy measurement of water, and but the lowest measure of products; a majority of those who till are too ignorant, and the minority who own the soil too indifferent to record their experience; the State does nothing to assist, and has no bureau to take cognizance of this most important factor of its chief source of wealth. Everywhere in the States or in Mexico private enterprise is supreme, and one learns only from private persons. The general condition is scanty collections of facts, and often opposite conclusions drawn from them.

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IRRIGATION SYSTEM AND LAWS IN MEXICO.

Remembering the immense extent of the arid area, and the magnitude of the irrigation already undertaken in it, one can not but be surprised at the nature of the legislation under which it has been developed. Still the omissions and mistakes made in the States furnish some valuable material. The Aztecs were experts in the art of irrigation when Cortez landed upon their shores, and the Spaniards who conquered them brought their "Law of Waters" into force in their possessions. Under the Montezumas, water was the property of the commune; under the Spaniards it become the property of the king. In both, the public interest was thus permanently recognized. Private acquisition was permitted for domestic purposes, but not for irrigation or industrial uses, except upon an authority derived from the crown or its delegates as representing the public interest. Property in water, however, can be acquired by uncontested possession for twenty years, and is superior to property on land, since its owner has the right to carry it over any land which may lie between its source of supply and the farm to which he wishes to appply it, on payment of compensation and justification of the route. There are a great variety of enactments relating to water in the several provinces and municipal districts; but as the water available for private use has been almost all appropriated, there is now little ground for litigation as to new diversions. Public rights are jealously guarded; a land-owner near the head of a stream may not deprive a land-owner lower down of his share. Unless he can obtain an official authority, he can use no water that is not derived from springs upon his own property. The chief measures of water are the sulco, which is equivalent to a flow of 0-23 cubic feet per second; the naranja, which is one-third of a sulco; and the paja, which is equal to 0-00053 cubic feet per second. In the City of Mexico and other important municipalities the paja is the unit of measurement nominally employed. Law suits relating to the use of water are not uncommon; but nevertheless the law, with all its defects, appears to be fairly comprehended and obeyed. In what were Mexican provinces, California, Arizona, and New Mexico, the practice of irrigation was established, though on a very small scale, before their annexation to the United States, and has since developed to a considerable degree on the same lines, the only cardinal principle recognized being that of one appropriator over another in the order of priority of use, the issue of Mexican grants and the wholesale incorporation of English common law having combined to confuse the legal position of irrigation.

COLORADO AND ITS IRRIGATION LAWS.

In all matters relating to irrigation the knowledge of what is to be avoided is of equal value with the knowledge of what is worthy of imitation, and this is particularly the case in regard to irrigation law. The enactments which have proved advantageous, and their particular deficiences, are both worthy of close attention. As the laws of Colorado are by far the most successful, they may be fairly allotted the first place. By the constitution of this State all streams within its boundaries were declared to be public property. By this one declaration a thousand and one sources of contention as to riparian rights were altogether closed. By special enactment it next provided for the proving and registry of every water claim. These were allowed by the courts in their order of priority, and to the amount of water which had been actually used. When these points had been adjudicated upon the claims were then published as rights. The consent of the state engineer was required before the issue of any further rights. Under a further provision the national value of irrigation was recognized as in Mexico by the granting of a general power to any person to obtain an easement for his canal over his neighbor's land upon payment of compensation. Twenty-six water districts were defined according to the natural areas of drainage and supply, and a water-master for each was appointed, whose duty it is to decide disputes between appropriators and supervise the general distribution from a particular stream. By these simple means a host of difficulties and complexities were escaped, permanence was given to existing works, and encouragement offered for the construction of new works. It is not surprising, therefore, that in mileage of canals or acreage irrigated, Colorado more than doubles any other State, or that its works are the greatest and most permanent, and are most rapidly extending. The Territory of Utah has shown its appreciation of such results by copying as closely as convenient the legislation of Colorado. Its powerful church government has proved an invaluable administrative, judicial, and organizing agency. In California a move has been attempted, and much less achieved. In that state there is no constitutional or statutory provision that the waters shall be public property, but the common law of England has been incorporated in the civil code of the State, so far as it is not repugnant to or inconsistent with the Constitution of the United States, or the constitution or laws of this State (section 4468); as a consequence the doctrine of the right of a riparian proprietor to receive from the riparian proprietor above, and his obligations to deliver to the riparian proprietor below the water of the stream upon which his land abuts undiminished in quantity and unimpaired in quality has been revived.

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CLIMATE AND IRRIGATION.

The irrigation area in America stretches from the snows of Colorado to the perpetual sunshine of Mexico, and from the shores of the Pacific to the valley of the Mississippi, embracing as great a variety of climate as is to be found in the whole of Australia. Over the whole of this great surface are scattered patches of irrigated land, and nowhere, north or south, east or west, does there appear to be any relinquishment of irrigation on account of climatic conditions. It is needless to add that, compared with the whole extent of this territory, the irrigated area is infinitesimal, but the fact stands that the high plains of Colorado, 5,000 feet above the sea, the bleak prairies of Kansas, the sandy waste of California at the sea-level, or the arid valleys of the Mexican plateau, 7,000 feet above it and within the tropical zone, are all susceptible of irrigation. The only want is want of water. Climate limits the Colorado farmer to a short season of one hundred days, while in Los Angeles or Leon cultivation is carried on all the year round. Climate determines the class of products that can be profitably raised, and temperature of course affects the quantity of water necessary to be used.

THE WATER SUPPLY.

Rain-fall.—The arid area of the United States, by the terms of Major Powell's definition, includes only lands where the rain-fall is under 20 inches per annum. Over the great belt in which irrigation has so far had its chief development the record for a series of years gives but a little more than half that quantity, so that 10 to 12 inches may be taken as a fair average, though the extremes show a much wider variation. In northern California and among the mountains to the east the rain-fall rises to 40 inches, while in the deserts of southern California it falls to 4 inches. In western Kansas the fall not infrequently reaches 20 inches, but this is so irregular that the farmer who relies solely upon a natural supply loses more by the dry seasons than he can make in those which are more propitions. The question as to whether settlement increase the rain-fall in the West as it has increased it in the Mississippi Valley is still undetermined, for though popular opinion is decidedly in the affirmative, the State engineer of Colorado points out that official records so far do not support the assertion. The exceptions to this are that Salt Lake, Utah, appears to be steadily gaining in depth and that dew is now observed at Greeley, in northern Colorado, a phenomenon quite unknown until irrigation had been practiced for some years. Nor does the mere amount of rain-fall indicate sufficiently the necessity for an artificial supply of water unless also the seasons in which it falls are taken into account. In parts of Dakota and Minnesota, where the rain-fall only averages about 20 inches, dry farming is carried on, while in districts of Texas, where the figures are as high, it would be impossible to obtain the same results without irrigation.

The explanation is that in Dakota nearly 75 per cent. of the rain falls in the season when the farmer needs it as against about 50 per cent. in Texas. Indeed a gradation may be observed in this scale from north to south, since in Kansas some 65 per cent. of the rain falls in the spring and summer, while in the extreme south, as at San Diego, only half of the whole rain-fall of 9 inches falls in the spring, and is consequently useless for agriculture. There is some irrigation in Dakota, as also in Iowa and Wyoming, but not nearly so much as in the States to the southward, where even if the rain-fall were as high its distribution would render it insufficient. The quantity of water needed is also affected by temperature, for the higher it reaches the more water is demanded. The loss by evaporation has not yet been determined for the several States, but it is stated that in very arid tracts it rises to over 60 inches per annum. The fact that irrigation is resorted to under such conditions should be borne in mind when we consider the wisdom of securing an artificial supply in places where the yearly fall is often sufficient.

Rivers.—That great backbone of the North American continent, the Rocky Mountains, traverses, with its companion, the Sierra Nevada, the whole of the Southwest, pouring from its snow-fields permanent streams in greater profusion that Victoria possesses. They rush from the rocky gorges out into the open country, running often bank high, and thus facilitating the diversion of their waters over the surrounding lands. But the majority of them are small, and where the supply is one peculiarity, of the utmost value in irrigation, is that they run along the ridges of the plain, while the country slopes away from their banks. In the south the rivers which supply the chief settlements are very shallow, and run in broad, sandy beds, often changing their course. The States have, as we have, streams which are a chain of pools for one-half the year, and often a torrent during the other half, while with them the melting of the snow supplies the water in volumes, as in the Murray, just when it is most required.

In Colorado the San Luis and Saguache dissipate themselves in the plains, while in southern California the Kern, in Utah the Jordan, and in Nevada the Carson, Truckee, and Humboldt terminate in lakes which have no outlet, thus furnishing

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parallels to the Wimmera, Richardson, and Dumnunkle of our own colony. One feature of many American streams, especially of those in sandy beds, is that they lose a great quantity of their flow by soakage, which in some cases returns to them by the same means. It has been observed of some rivers in New Mexico, as in Italy of some tributaries of the Po, that the stream tapped by a large irrigating ditch and robbed of a considerable share of its flood, regain it all again a few miles lower down. It has been found also that old river-beds still carry a flow underground, and that some running rivers have but a fraction of their streams above ground. In California sometimes as much as two-thirds of a stream has been found below its bed, and consequently what are called submerged or subsoil dams have been occasionally employed with great success, as in the Santiago Valley and at Downey, to arrest these escapes and bring the whole body of water to the surface. Another characteristic of American rivers is that no matter how clear the water may appear it almost invariably carries with it a sediment, which is in the majority of cases a valuable fertilizer. There are rivers, such as the King's River, California, which are said to carry no silt, and yet to fertilize the land, in which case it is to be presumed that the water acts as a solvent, disintegrating the coarser particles of the soil and preparing the fertilizing elements for absorption in plant growth. The topography of this State, California, has been especially favorable to small schemes, and has induced the farmer, by his opportunities of obtaining water when he most needs it at a minimum of labor and expense, to commence experiments on his own land.

Springs and wells.—In the matter of the supply obtained from underground, American experience is, on the whole, encouraging. In Los Angeles and San Bernardino Counties, Cal., there are springs or springy marshes called cienagas which irrigate from 20 to 400 acres each, and together supply an area of 7,000 acres of cultivated lands. Such springs are an important source of supply in Italy, where they are styled fontanili. Here some are so charged with mineral matter as to be unfit for use and have usually so small a flow as to be employed for orchard irrigation only. At San Gabriel, Cal., a vineyard 1,200 acres in extent is supplied solely by springs or artesian wells, of which there are twenty-one on the estate, ranging from 75 to 100 feet deep. In southern California, altogether there are calculated to be one thousand of these wells, varying in depth from 200 to 550 feet; some of them have a flow of 1.7 cubic feet per second, and suffice for the irrigation of small farms. On one estate there are fifteen of an average depth of 200 feet, yielding water at the rate of 2.2 cubic feet per second. Artesian water has been, if anything, rather dearer than canal water in California, but has the advantage of being at a higher temperature than snow-fed streams.

In Santa Clara County, Cal., there is an artesian tract yielding 2,000,000 gallons every twenty-four hours, but the greatest supply from such sources is at Denver, Colo., where a stream of 2,880,000 gallons per day is derived from eighty wells, which range from 300 feet to 900 feet deep. In sinking these the "club-churn" drills have been found cheaper and quicker than the diamond drill, sinking 45 feet in twelve hours, as against 15 feet with the diamond drill, or 90 feet in twenty-four hours as against 35 feet. When artesian water is used the wells are, where possible, put down upon the highest part of the farm from which the water can be most easily distributed; when the water is raised by means of a windmill from an ordinary well, which is usually upon low ground, it is delivered into a light wooden flume, which conveys it into a reservoir on some commanding spot. In California, and especially at Florin, water is raised from depths of 10 to 20 feet in a steady stream by means of windmills, one of which, as a rule, can supply 2 to 3 acres of land with water. Further south the water is raised from more than twice this depth by the same means. In most cases the water is bored for and struck, but does not rise to the surface, the windmill being employed to lift it the extra distance. If water were found without boring at 10 feet deep irrigation for vines or lucern would be considered superfluous. The utilization of such small quantities of water as can be obtained by these means attest the value set upon any supply, however minute. Though the streams of the West are considerable in number, they are small and far between in almost every district in which irrigation is necessary. There are most extensive areas without appreciable rainfall, without rivers, and without springs. The irrigable area is narrow and widely distributed, occurring, except in Colorado and Kansas, in comparatively small allotments.

IRRIGATION WORKS AND THEIR CONSTRUCTION.

It is next desirable to consider the means by which water is diverted and the methods of its application, so as to share any knowledge which Americans possess in these directions. To comprehend the nature of their works it is desirable to bear in mind their history, for they have rarely been the result of one foreseen plan, but have, as a rule, been brought into their present condition piecemeal. It must be remembered that they are not State works, and that in many cases they were not constructed by companies or capitalists, but by the farmers themselves, either singly or

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banded together. On the faith, perhaps, of a good season the settler had taken up land and after his crop was in had seen himself in danger of losing it, or else in sheer desperation he had settled without expecting a rain-fall and determined to try the Mexican custom of flooding his fields. In either case his necessity has been the same. He must have water or be ruined. If it did not fall from the clouds he has asked himself why it should not prove as efficient if obtained from the nearest stream. With this pressure upon him he has not waited to inquire into his legal rights or seek for engineering skill or hold public meetings. He has hitched his team and with plow and spade run a rough ditch to the river bank. By cutting this through, and if necessary throwing up a slight wing-dam to turn the water in, he has been able to soak his fields, save his crop, and probably get half as much again as an ordinary yield. Stirred by this gain, and by a strong sense of successful self-reliance, he has made his work permanent. A neighbor has joined him in enlarging the ditch, and then shared in its benefits. Others have been encouraged to face the same task. Where several were interested they have joined their forces, apportioned the work, and each carried out his share or paid for its being carried out for him. By these means a great number of so-called works have been constructed, and, learning from them, the small capitalist and the large capitalist have followed suit, and have built canals to supply water for use upon their own lands or upon lands which they wish to let or sell, or upon the lands of others to whom they intend to dispose of the water they have secured.

These works have been built often without engineers, almost always without plans, and their defects are patent. The weir head-gate or wing-dam, as the case may be, has been carried away several times, and has probably cost more to replace than a substantial structure might have cost. Then the easiest courses for the ditches have been chosen, so that, instead of running on high land, they have even followed old water-courses, and thus have commanded from the canal a much smaller area and more imperfectly than they should have done. There have sometimes been no surveys, and as a consequence curves have been too sharp and grades too steep, so that ditches gradually destroy themselves, cutting out their own banks and filling in their beds. Or, perhaps, an opposite fault has been committed, and there has not been current enough to keep down the water weeds which spring up in the channel and choke it.

Then, again, the natural result of individual effort of this kind has been that several canals have been built where only one was necessary. For instance, there are five ditches supplying the Mussel Slough district, California, where one would carry all the water with far less loss in the carriage. There are thirty-two canals taken out of the Kern River, where eight would have been abundant; and at Fresno half a dozen where two would have sufficed. What loss this involves may be estimated from a calculation of the State engineer, who, after a careful examination of two of these canals, finds that their combined stream could have been carried in one channel at a saving of 20 per cent. of the water conveyed. The engineering defects of such works are palpable, and are not disputed or disguised. At the same time it would be a mistake to condemn them out of hand. At least they have served their purpose for a time—it may be wastefully, but the waste could not have been prevented. Crop after crop has been saved—the farmer has kept his land, has built his house, and cultivated his plot comfortably by their means. If he now possesses the knowledge needed to irrigate and build ditches, and has the money in his pocket to enable him to use his knowledge, he owes it all to these first rude efforts of his by which he put the water upon his fields cheaply and without delay.

Everywhere, however, engineering work is characterized by extreme simplicity and economy; it is rarely massive and never ornamental. There is no attempt at finish, but only at efficiency. Water-works in the West are like railways, often made to pay for their own construction. At first just enough work is done to enable them to yield a return, and then additions are made from time to time, until at last they are brought into a condition of stability. In places where it is cheaper to build a new weir or wing-dam of brush and sand every year than to pay interest upon the sum required for a permanent structure the temporary work is invariably resorted to.

It is rare also that any work is built strongly enough to endure all contingencies. The practice is to put up a weir that will stand in ordinary seasons, foreseeing that it will be swept away by the first of the heavy floods which occur periodically every few years.

There are many ingenious engineering devices for decreasing expenses, but this principle of risk to save interest governs all. American engineers know that these works are not permanent when they build them. As a rule they have the professional dislike of building temporary works, and, not having to provide the funds, prefer structures that will prove a lasting credit to them; but shrewd capitalists have tested the principle in practice, and they find it pays to resort in many cases to these slighter works.

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SOME OF THE PRINCIPAL WORKS.

Among th eillnstrations of this combination of risk with very clever engineering there are none better than those to be found at Bakersfield, where Mr. James, as engineer for Messrs. Haggin and Carr, has had a large field for the display of his ability. Timber is cheap in America, and California is favored with the redwood, which is soft, easily worked, and yet durable; consequently it is almost wholly employed by Mr. James upon his 250 miles of canal. His main gates cost from £40 to £60, while his head-gates, controlling a flow of 30 feet or 40 feet of water 3 or 4 feet deep, are erected for £600. A wooden weir in the Callaway Canal, costing only £2,600, is 700 feet long, can be put in place in a couple of hours, and is ingeniously arranged so that its superstructure is rapidly removable. Many of the contrivances employed on these ranches are well worthy of imitation wherever shallow streams are to be dealt with in a level country. The combination of weir and bridge in the same wooden structure is another feature of these works well worth the attention of local governing bodies, one of these, 360 feet long, 20 feet wide, raising the water 5 feet, and reckoned to have a life of at least twenty years, being built for less than £2,000.

In the streams of southern California, which are of no great depth as a rule, brush-work is generally used for weirs and dams, sometimes being loaded with sand-boxes or sand-bags or protected with fascines, loaded down with cobble-stones. Thus the San Joaquin and King's River Canal, California, has such a wing-dam, 350 feet long, as has the Larimer and Weld Canal, Colorado, where the dam is 177 feet long and 5 feet 8 inches high. Examples of this class of construction on a great scale, though not for irrigation, may be found in the Yuba and Bear Rivers, where two dams may be seen, one of them 8,900 feet long, and the other 5,875 feet long, ranging from 3 feet to 15 feet in height, and from 60 feet to 120 feet in width. Perhaps the largest irrigation head-work in this style is that of the Eureka Canal, in Kansas, which is 1,500 feet long and 8 feet high, supported by a dike a mile long on the south side of the river, and diverting 5 feet of water through a cut in the banks of the Arkansas, 16 feet deep, into a canal 28 feet broad at the bed and 80 miles in length. The dimensions of these works, together with the stability of such head-gates as that upon the 76 canal, Fresno, Cal., which is also a bridge of 100 feet long and 20 feet wide, and raises the water 5 feet at a cost of £1,000, and the ingenuity of the head-gate of the Chowchilla Canal, resting upon a quicksand, as described in the engineer's report, are evidence enough of the ability which is displayed in many works. In northern California there are both dams and weirs, of great height and excellent simplicity of structure, erected for mining purposes, and now, in a few cases and on a small scale, utilized for irrigation as well as motive power. For the most subtsantial of all head-works, however, we must look to Colorado.

There are some small stone weirs in the South, and some fine pieces of masonry work of great antiquity in Mexico, but none of these are liable to such enormous strain as is met with in the wild cañons of the Rocky Mountains. The South Platte Weir, for instance, is 120 feet long from the cliff on the one side to its waste-gate of solid masonry, 24 feet wide, on the other, raising the water 14 feet by means of a frame-work of 12 by 12 timbers bolted into the bed-rock, filled with stones and planked on the face with 6-inch boards. The apron extends 54 feet up-stream and 18 feet below the weir, the water having a perpendicular fall. The waste-gate and off-take are both protected by substantial "booms" or "grids," the latter 72 feet long, built of 12 by 12 timbers. These admit the water through bars below the surface and protect the work from the trunks of trees, which are carried down with great force when the stream is high. These "booms" are in frequent use in Colorado, and are worthy of note for application upon the many Australian streams in which heavy floods invariably whirl along with them great quantities of timber with a force that would destroy an unprotected structure as speedily as a battering-ram. The weir across the North Poudre endures even fiercer floods, and is more massive in structure, stretching 160 feet across a rugged cañon, from wall to wall in the form of an arch, bending up-stream, and composed of strong cribs filled with stones; it raises the water 26 feet into its flumes. The lower face consists of three steps pitched with stones, which are so keyed in each other that the pressure upon them only serves to wedge them more firmly in. As it has stood two or three severe floods without sustaining any damage it may be considered a success, more especially as though situated in an out-of-the-way district over 20 miles from the nearest station, and a mile up an almost inaccessible gorge, its cost was less than £2,000. It was considered worthy of being made the chief subject of a special paper read before the Institution of Civil Engineers in London.

Enough has been said here to indicate the character of the chief classes of head-works, of which there are a great variety in each State. The minor works, such as drops, gates, or regulators, are usually of wood, and of simple design. In the South Platte Canal a much superior gate may be seen, the off-take from the main canal being by means of an earthenware pipe set in stones, beyond which is the usual gate

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and a measuring weir. The head-gates, however, include but a small part of the works undertaken in order to secure a supply of water. There is a prevalent idea that in America the streams only require to be touched with a spade to pour themselves upon the farmer's sown lands. That such is not always the case in Colorado may be seen from the fact that the South Platte Weir referred to above, built at a cost of £4,000, serves to raise the waters to the level of a tunnel 600 feet long, 20 feet wide, and 12 feet high, hewn through the solid rock, at an outlay of £12,000, emptying its tide into a wooden flume 2,640 feet long, 28 feet wide, and 7 feet deep, which cost nearly £20,000, and is supplemented further on by other wooden flumes along the 83 miles for which this artificial river has been excavated across the plains. The North Poudre Canal has about a mile of wooden flumes, and three tunnels, one of them 900 feet long, necessitating an outlay of £10,000 for its first mile before it touches the open country, through which it flows for 50 miles. Nor is expenditure of this character limited to great canals supplying large areas. The price that can be paid for water may be better understood by noting what the outlay is upon small areas.

At Pasadena, where there are but 1,500 acres to supply, the water is carried from the weir by a flume 700 feet long into an iron pipe 3 miles long, from 13 inches to 11 inches in diameter, to a reservoir with a capacity of 3,000,000 gallons, party rock-walled and partly cemented. From this another iron pipe conveys it to the land to be irrigated, while a lower portion is supplied from another source by a pump throwing 30,000 gallons an hour into another 500,000-gallon reservoir, from which it is distributed by a mile and a half more of iron piping. The total cost of these works is given as £8,000. The Lake Vineyard Company to the east have a concrete ditch 17,000 feet long and a quantity of iron piping simply to water their own vines. The supply to the neighboring colony of Anaheim is carried in a flume 6,970 feet in length. At Redlands there are 6 miles of iron piping 1 foot in diameter, carrying 5 cubic feet of water per second from the weir to the 2,400 acres which it is intended to irrigate, upon which there are stand-pipes and iron measuring weirs to every allotment. At Ontario, with its 8,000 acres, the arrangements are equally perfect, a large portion of its supply being obtained by a tunnel nearly 3,000 feet long, upon which £10,000 have been spent. An illustration of another class of water-works on a great scale may be seen among the mountains of Nevada, where there are wooden flumes from 50 to 80 miles in length, down which sawn timber is floated from the forests among the hills. The distance which great streams of water have to be carried before they can be utilized may be judged from a few illustrations.

The Dodge City Canal, Kansas, is 90 miles long and 50 feet wide; the San Joaquin and King's River Canal, California, 78 miles long and 68 feet wide; the South Platte, Colorado, is to stretch 160 miles when completed; while the Great Eastern, Kansas; the 76 Canal, Fresno, Cal.; the Larimer and Weld, Colorado; the Arizona Canal, Arizona, all range from 40 to 60 miles in length, with a breadth of over 30 feet. In considering the length of these canals, it should be remembered that some of them have been carried much farther than the natural circumstances required, passing irrigable lands in their course just as rich as those they reach beyond, but which are unsupplied because they do not belong to the proprietor of the ditch. The area of irrigable land under canals of these dimensions amounts often to from 50,000 acres to 250,000 acres each, but from none as yet is more than the smaller quantity under cultivation. In Utah, settlements have been abandoned because they were located too far from the streams supplying them. The higher up-stream an off-take of a canal is, and the shorter the distance water is carried to land, the less the loss by soakage. The more favorably situated flats, however, usually lie farther down-stream, and as these are always the first to be irrigated it becomes necessary for the later settler to take up higher ground, to water which he must go farther up the river. There is thus a tendency for the canals to become longer as the country is taken up. It is unnecessary to describe their construction, for they are merely ditches of sizes and grades varying according to the soil in which they are cut and the water they have to carry, which is from 1 cubic foot to 2,000 cubic feet per second. The average cost of a 30-foot canal is reckoned in ordinary country at from £200 to £300 per mile by Colorado engineers. The average grades chosen are from 1 to 3 feet per mile; the banks, in most places, being on the slope of 4 or 5 to 1. The breadth is adjusted so as to equalize the discharge, being greatest where the grade is least.

The amount of money which private persons have invested in these works shows that the prospects of profit are tempting. The San Joaquin Canal represents in direct and indirect outlay £260,000; the Dodge City, £160,000; the South Platte, £150,000; the Arizona, £100,000; the North Poudre, £50,000, and the City Ditch, at Salt Lake, £45,000. Several of these are built by companies which have other canals of considerable size and land purchases made in connection with them, in which even larger sums are sunk. Two companies in Colorado control between them nearly 500 miles of main canals, which, together with the land they were constructed to water, rep-

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resent an outlay of more than half a million sterling. As far as can be judged there are no apprehensions entertained as to the future of such investments; their proprietors appear satisfied with their returns up to the present time, and not unwilling to enter upon extensions of their existing enterprises. Still the figures, even now, should make it plain that irrigation in America is not the simple matter it has been supposed, but one that taxes the capital and enterprise of even a speculative people.

THE PRINCIPAL IRRIGATION RESERVOIRS.

Next to head-works, the most important feature is the provision of storage, by means of which the surplus of winter rains or spring floods may be retained for use in time of need. The surveys made in California and Colorado so far have discovered many natural depressions of no great extent, but still valuable in connection with irrigation schemes. In Los Angeles County are to be found a number of reservoirs already built, some of them cemented; others, such as those of the Lake Vineyard Association, composed of the natural soil. Most of these are small, the largest containing 21,000,000 gallons. The cost of excavation here was from 7*s.* 6*d.* to 12*s.* 6*d.* per thousand cubic feet of storage. In New Mexico, by means of a series of earthen dams, one farmer has created seven reservoirs, from which he can command, with a reserve supply, some 2,000 acres of his estate. In Colorado the mountainous character of the country has been favorable to the construction of similar works, the State engineer recording a number of them at 6 feet to 35 feet deep and 10 acres to 500 acres in extent. The largest is that in connection with the Big Thompson Canal, which covers 427.35 acres to a depth of 35.8 feet, of which 21.8 feet is available, and is expected to water 12,000 acres. A chain of such reservoirs is being added to the North Poudre works previously referred to. But by far the greatest of these reservoirs is situated in the Bear Valley above Riverside and Redlands, Cal., where, by means of a wall of masonry 300 feet long and 60 feet high, 8,000,000,000 gallons, or more than the contents of the Yan Yean when full, are preserved, owing to exceptional natural advantages, at a cost of £12,000. This will give a continuous stream of 150 cubic feet per second for 100 days, which, on the scale of supply adopted at Redlands, should water at least 50,000 acres. A still larger reservoir is projected in southeastern Colorado, where water sufficient to supply 100,000 acres is to be stored, in connection with a canal 80 feet wide, 7 feet deep, and capable, with the reservoir, of irrigating twice that area.

CONSTRUCTION IMPLEMENTS.

The implements themselves are various, and a considerable portion of the saving is made in the knowledge when to use one and when to replace it by another. To begin with the simplest kind of construction, that of field ditching, the farmer does this, as a rule, with his plow, with which he can easily run a ditch of a few inches capacity across the field. If he intends to widen it while keeping it shallow he employs the ditch plow, which consists of a blade suspended behind the share so as to push the earth which it cuts to one side. In many soils this is found to be an invaluable implement. When the work is more roughly done, what is known as a V scraper is brought into play. This varies from a mere log of wood with a couple of old spade heads nailed in front, forming a sharp prow, which is its rudest form, to a triangle some 6 feet wide at its wooden base, from which proceed two long iron blades forming the acute angle. Its use is always the same. It is drawn by horses and steadied by the driver's weight, so as to push the earth outward from a simple plow furrow or series of furrows, and thus form a ditch. When this is over 6 feet in width a "side-wiper" is generally substituted, which is a long iron blade, lowered from a frame which rests upon four wheels, so that when drawn by a powerful team it slants the plowed soil to one side. In light soils and for large ditches an elaborate machine is used, which not only plows the earth but takes it up and shoots it out upon the banks a distance of 10 or 12 feet, to either side, at the rate of from 600 to 1,000 cubic yards per day.

But the implement most in use for operations of any extent is the iron "scraper," which is found in many forms, sometimes runs sledgewise, sometimes upon wheels, and ingeniously fitted so as to be tilted without effort. For a long pull wheels are considered best, and for steep banks runners have the preference, but scoops are preferred without either for sandy soil. The kind of soil to be moved and worked upon and the length of haul are always taken into account in determining the class of scoop used. In constructing a deep canal a haul of 1 foot upward is reckoned the equivalent of 50 feet on the level, and with an experienced driver and a team or two of horses or mules a scoop is expected to remove from 80 to 120 yards per day. Sometimes in railway work one man is told off to every four teams to fill the scoops, but in the majority of cases the driver does this himself. There is another implement known as the buck scraper, which for ordinary farming use in light soils and in practiced hands accomplishes remarkable results. It consists of a strong piece of 2-inch timber, from 6 feet to 9 feet long and 1 foot 3 inches high, with a 6-inch steel plate

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along its face projecting 2 inches below its lower edge, and is strengthed with cross-pieces at the back, where there is a projecting arm, upon which the driver stands. Like the ordinary scraper, it is also found on wheels and runners and in many patterns, and is drawn by a pair of horses. Instead of taking up the earth as the scoop does, it pushes the soil before it, and when under good command does such work as check-making, ditch excavating, or field leveling, in sandy soils, with marvelous rapidity. Work with the scoop costs, as a rule from 4*d.* to 6*d.* per cubic yard; when the cost reaches 9*d.* it is considered time to set it aside.

With the buck scraper work has been done in favorable localities as low as 2*d*, and even a penny, per cubic yard; and it is astonishing to note the number of uses to which this simple implement is successfully applied. Where the leveling of fields is difficult a machine is sometimes used which cuts off the tops of mounds or ridges and drops the stuff in the first hollow over which it passes. The windmills for raising water from wells have been already alluded to as have the boring machines at Denver. Where the water is to be raised from a running stream a wheel is employed turned by the current, raising little bucketsful and pouring them into a wooden flume from 12 feet to 20 feet high. Many little contrivances, such as a movable iron grate or "tapon," for diverting water at any point from field ditches, and shaped like a railway disk, are to be met with.

DISTRIBUTION BY PIPES.

In this connection it may be well to notice the variety of pipes employed for water supply and likely to be more employed as water becomes scarcer and fruit raising increases. Where suitable material is at hand it is not uncommon to find ditches, as at Lugonia, Cal., roughly paved for 6 or 7 miles, thus saving one-third of the water previously lost in this distance. Again, the South Fork ditch, from the Santa Ana, is made in a similar way, by neatly fitting cobblestones together, and with an equally satisfactory result. Near Passadena, as already mentioned, there is a concrete ditch more than 5 miles in length. This mode of ditching, however, is not always possible, and where such an outlay can be faced it is generally advisable to use pipes. The greater profits realized from fruit-growing encourage such an expenditure, by means of which a very small stream can be made to cover a comparatively large area.

Pipes can either be employed to bring water to land upon which it is to be used or they can also be carried on so as to distribute the supply throughout the cultivated area. This latter process, known as subirrigation, will be described at a later stage. When it is practiced a simple machine is generally used, by means of which a cement pipe is made in the ground and in position, thus saving the risk of transportation and some cost of labor. The scale on which this has been attempted is not as yet sufficient to demonstrate its universal efficiency. For main channels a concrete pipe, cheaper than earthenware piping, is largely in use in the "colonies" of southern California, as at Ontario and Pasadena, where it has proved durable and serviceable under low pressure. In the San Demas Cañon there are 3 miles of this pipe, 5 inches in interior diameter, carried along the face of a cliff. Its most formidable rivals have been a riveted and asphalted pipe and a light laminated pipe, both of wrought iron, the latter made by telescoping one sheet-iron pipe into another when submerged in asphalt and tar, and thus filling up the small space between them with the mixture. As a 4-inch pipe of this pattern is supplied for practically the same price as that in cement, and has proved itself capable of withstanding great pressure, the preference, on the whole, appears to be given to the iron. Where it is found, as in Utah, that a ditch 3 feet deep, which is 20 feet wide for the first 23 miles of its course, can in the next 2 miles carry all that is left of its stream in a width of 12 feet, it becomes plain that where water is valuable there is a fair margin to pay for piping.

METHODS OF IRRIGATION.

Flooding.—The earliest, easiest, simplest, and cheapest method of irrigation is by flooding. The water is then directed so as to cover the whole area under cultivation to a depth varying according to the crop and the quality of the soil. This plan is the most wasteful of water, but can not be avoided in the cultivation of cereals. The only work it involves in the field is that necessary to permit an even flow of water. With a regular slope this work is sometimes trifling, but as a rule some preliminary outlay is required for leveling inequalities, or else providing for the equal distribution of the stream from points of vantage. When the fall is slight, shallow ditches are run in Colorado from 50 feet to 100 feet apart in the direction of the fall; when the land is steeper they are carried diagonally to the slope or are made to wind around it, and from these, by throwing up little dams from point to point, the whole field is inexpensively flooded. When the fall is still greater and the surface irregular ridges are thrown up along the contour lines of the land, marking it off into plots called "checks," on the whole of the interior of which water will readily and rapidly reach an equal depth. When one plot is covered the check is broken and the water admitted so as in the same way to cover the next plot.

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The ridges or "levees" must have rounded crests and easy slopes, or else they interfere with the use of farming machinery, such as the stripper. By means of diagonal furrows and checks remarkable results are obtained, even in very broken country. By their means it is claimed that in Colorado one man can irrigate 25 acres per day. Where checks have not been used upon ground with an acute incline, the water has soon worn deep channels through it, utterly ruining it for agricultural purposes; or again, where the water has been allowed to flow too freely the consequence has been that all the fertilizing elements of the soil have been washed away. In flooding the aim is, therefore, to put no more water upon the land than it will at once and equally absorb or can part with without creating a current sufficient to carry off sediment. The neglect of these precautions has caused the abandonment of several settlements made in Utah before the art of irrigation was properly understood.

In southern California checks are employed even more successfully than in Colorado, the levees being built by buckscrapers, so as to prepare large areas for crop at 2*d.* per cubic yard of material moved, or 6*s.* per acre.

The lands there are not so rolling as in the northern uplands, where the average cost of preparing land for irrigation is from 8*s.* to 16*s.* per acre. As much higher estimates have been given in Victoria, it should be noted that the higher price is for country more difficult than the average of our northern plains. It would be possible, by grading and terracing, to water very steep slopes, but the labor would not be paid for by any cereals that could be raised. Both the depth and number of floodings are varied according to soil and crop. With a clay soil the waterings are light and frequent, while with a sandier quality they are heavier and rarer. Much, too, depends upon the distance and nature of the subsoil. There is considerable uncertainty with regard to the measurements given for flooding. It is sometimes placed as low as will give a depth of 2 or 3 inches, and at other times as high as from 5 inches to 10 inches at a single watering.* There are cases in which as many feet have been used. The number of waterings is best determined by the crop itself, and the most skillful irrigators are those who study its needs and take care to supply them without giving an excess of water. The quantity used alters, therefore, from season to season, so that only an average can be given.

In Colorado, where water is used more lavishly than in any other State, some good judges have agreed that an average of 14 inches should be ample, and this is certainly not too low. Where the soil is liable to become hard and will retain moisture, wheat is often grown with two floodings, one before the ground is plowed, and the other when it is approaching the ear. When two waterings are given after sowing, one is when the wheat commences to "tiller," and the other when it reaches the milky stage. Where irrigation does not precede the plowing, it is postponed as long after the appearance of the crop as possible. Sometimes wheat has three or even as many as four floodings; but this is unusual, as overwatering occasions "rust." Experience shows that it is easy to exceed the quantity required by the crop, and that every excess is injurious. Extravagance is the common fault, so much so that the most successful irrigators are invariably those who use the least water. The less water, indeed, with which grain can be brought to maturity the finer the yield.

Furrows.—Peas and potatoes are not irrigated by flooding, but from furrows 4 feet to 10 feet apart, and this is found the more economical and more successful system for vines and fruit trees.

Under the flooding system, the ground, if not protected from the sun, cakes quickly. When the water is run down furrows drawn by a plow between the plants, this caking is avoided, and the water soaks quietly to the roots. When flooding was practiced in orchards it was found to bring the roots to the surface and enfeeble the trees, so that they needed frequent waterings. Sometimes the furrows feed a small hole at the foot of the tree, from which the water soaks slowly in. When this is done mulching is found desirable over the hole to reduce the loss by evaporation. The general rule is to protect the trees by small ridges, so that the water does not affect the surface within 3 or 4 feet of them. The simple furrow, however, is most generally in use. Oranges are watered three or at most four times in summer; vines, once, twice, or often not at all after the first year or two; and other fruits according to the caprice of the owner, the necessities of the season, and the nature of the soil, one to four times. It is impossible to be more exact. An even greater difference, comparatively in the quantity of water used, obtains in the furrow irrigation of fruit trees and vines than has been noted in regard to cereals. To such an extent does this prevail, that not only do districts differ, but, of two neighbors who cultivate the same fruits in contiguous orchards, having exactly the same slope and soil, one will use twice or thrice as much water as the other. Judging as far as possible from conflicting testimonies, the cardinal principle appears to be just the same. To attain the best results the trees must be carefully watched, and supplied with only just enough water to keep them in a vigorously healthy condition.

Another all-important principle, as to which there is no question, and which is testified to on every hand, is that the more thoroughly the soil is cultivated the less water

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it demands—a truth based partly, no doubt, upon the fact that the evaporation from hard, unbroken soil is more rapid than from tilled ground, which retains the more thoroughly distributed moisture for a longer period. For the irrigation of cereals, works are required on a larger scale proportionately than for fruit; because in the first case the water is demanded in greater quantities at particular times, while in the latter the supply can be more evenly distributed throughout the year, though of course the irrigating season with both is much the same. In the Northern States irrigation is limited to a hundred days, while in the South it can be employed at discretion all the year round. In both regions winter and autumn irrigations are growing steadily in favor. Land which receives its soaking then needs less in summer, and is found in better condition for plowing. It is argued that moisture is more naturally absorbed in that season and with greater benefit. Everywhere the verdict of the experienced is that too much water is being used, and the outcry against oversaturation in summer is but one of its forms.

Sub-irrigation.—Irrigation beneath the surface, if not excessive, is considered the most perfect method of supplying water to vegetable life, and it has been the aim of many to devise a scheme by which this can be done with the greatest economy. The idea is to replace soakage from above, by either flooding or furrows, with what is called "seepage;" that is, subterranean and lateral soakage, which, to be perfect, should not wet the surface. The one advantage possessed by surface over sub-irrigation is that, when carefully managed, irrigation by soakage is a perennial source of fertilization, on account of the quantity of deposit which is obtained with the water from most streams in certain seasons. Irrigation by seepage can not produce this beneficial effect, but it can avoid the dangers of excessive saturation or surface caking, or of washing out the richer elements of the soil, as well as accomplish an enormous saving in the water used. Two difficulties have presented themselves to its complete success. The first of these is the tendency of the apertures in the pipes to become choked by the roots, which tend to form a mat about it. The main difficulty, however, so far rather feared than experienced, is that the constant seepage of water would have such a solidifying effect upon the soil, closing its pores and converting it into an almost impenetrable mass, that it would become necessary, after some years, to break it up to a considerable depth by cultivation. Of this it is too early to pronounce, but it certainly appears that sub-irrigation is the hope of most intelligent irrigators, because it promises a great economy of water, and the most direct application of it to the thirsty tree that it is possible to devise. The average cost of making and laying pipes for sub-irrigation is given by an authority at £7 per acre, a sum which the owners of land under intense culture could afford to pay.

Open ditches are wasteful.—The present practice is the most wasteful that could be devised. There is waste along all the miles of open canals, both main and secondary, with a consequent loss to the owers of from 25 per cent. to 50 per cent. of the stream they take in. Sometimes it is even greater, a canal in the San Joaquin Valley, which took in 90 cubic feet per second at its head, only delivering 14 cubic feet per second on the farms 28 miles away. Where the canal owner's loss ends, that of the farmer begins. He loses all along his laterals tapping the secondary canal; all along his sub-laterals intersecting his farm, and again, all that is not absorbed by the crop over which he pours his periodic flood; besides which has to be added the loss from evaporation. As a matter of fact, therefore, he only receives the benefit of a very small proportion of what he pays for. Some put the loss of farmer and canal proprietor together as high as nine-tenths of the water diverted; others at three-fourths, and it is rarely calculated at less than the latter figure. There is certainly ample room for saving at every turn. In Utah, as in Italy, another economy is effected by requiring those entitled to water to take it at night as well as by day, so that instead of the supply running to waste for eight to ten hours out of the twenty-four, the whole capacity of the ditch is utilized every minute during the irrigating season. This custom has the further advantage that the water is thought to act more favorably upon the soil by night than if it were under the burning rays of the sun. The manual labor or skill required for controlling water is not great, and it calls for patience and attention rather than activity. To see the irrigator, spade in hand, engaged in a leisurely way, directing the stream gushing from his ditch, it would scarcely be suspected that upon so unimpressive a proceeding the whole future of the orchard in which he is engaged entirely depended. There seems an incompatibility between causes and effects which asserts itself in many ways, so that it becomes an effort to realize that the rude ditches which wind their rugged banks across trim fields or among regular rows of vines or orange-trees, are actually the generous source from which all the profusion of foliage and fruit is being invisibly fed.

FERTILIZATION BY IRRIGATION.

Part of this incompatibility no doubt arises from the fact that there is something more than water conveyed in canals, and that this something more is extremely valuable, though usually left out of the calculation. Water of itself can work wonders, but when allied with sediment, which in nine cases out of ten appears to consist either of decayed

vegetable matter or to contain elements that replenish the soils by which it is absorbed, the results become multiplied. In France the practice of pouring large bodies of water heavily charged with sediment upon inferior lands for the purpose of reclaiming and enriching them is extensively adopted. This is not systematically attempted to the same extent in America, though the sandy sage-brush lands of Utah and Nevada have been turned into rich meadows in the same way; but it is generally recognized that where irrigation is so controlled as to admit of just as much water being placed upon the land as it can drink at a draught, without allowing it either to stand or run away, then the consequence is invariably a maintained or an increased production. Not only is the crop secured, but whether it be grain, root crop, or fruit, the yield is often largely enhanced so as to reach, in arid regions or upon poor soils, a yield equal to that obtained upon fertile lands enjoying a plentiful rain-fall. Farmers' estimates of what this gain actually is differ considerably, ranging from 30 to 100 per cent. That there is a gain, and a great gain in many instances, no one thinks of disputing, though there may be some looseness in the figures quoted concerning it. There seem to be no products of which the crop may not be increased by irrigation, and there are none that will not suffer from over-irrigation. The richest silty water, instead of having a fertilizing influence, will be fatal if allowed either to stagnate or to rush too rapidly through a field. But with this danger provided against, irrigation may mean fertilization to such an extent as to render any further artificial enrichment of the soil unnecessary. In most parts of the West this has been the only fertilization which has maintained land under years of cropping.

IRRIGATION DRAINAGE.

As a matter of fact there are no drainage works worthy of the name in America, the farmer having quietly left the water to settle this problem for itself. Water is always valuable in these regions, and what one farmer allows to flow by another is only too eager to acquire. Canal proprietors have not found any necessity to spend money in making provision for the surplus water which passes their area of supply, as it is generally extremely easy to let it find its way into the natural water-courses which run at lower levels than the artificial stream. How to get water is the one question of importance; how to get rid of it has been found in nineteen cases out of twenty only too easy. With a deep subsoil or a good fall it seems as if drainage may always be unnecessary, and these are conditions very frequently met with. There are, however, lands comparatively level in which, sooner or later, it will be required; and there are one or two localities in which the need of drainage-works is rapidly becoming an imperative necessity. Among these by far the most striking illustration is furnished at Fresno, Cal., a district in which the same facts are also extremely valuable as indicating the change in character of an arid plain submitted to years of extravagant irrigation. Fifteen years ago its sandy soil, sparsely covered by struggling herbage, grassless and treeless for scores of square miles, maintained only a few herds of cattle. There was no sign of cultivation within its borders; water could only be obtained by sinking from 40 feet to 80 feet, and the rain-fall was both irregular and insufficient. The King River, which was its one available stream, sometimes carried no more than 500 cubic feet per second, and when the first "colony" was established it was stoutly maintained that the whole of its waters would not suffice to supply this little plot marked out in the midst of the wild.

For some time—indeed, even after the canal to supply this colony had been constructed—so rapidly did the open ditch absorb the intake that it was thought that the water would never reach the settlement at all. Week by week the tiny thread of fluid trickled and wound its way along; at last, it entered the fields prepared for it, and, the flow steadily strengthening, crept farther and farther on, feeding an ever-widening district, until to-day there are fifteen canals drawing their waters from this river, irrigating 55,000 acres of land, which form a chain of settlement all around the central Californian colony, and extending 16 miles beyond it. Water can now be struck anywhere across the whole plain at 10 feet, and often at 6 feet. The seepage from the canals has been great indeed, for it seems to have filled the whole subsoil, which has sucked it up like a sponge until it can hold no more. One important consequence is, that irrigation by flooding or furrows is being abandoned at Fresno, as the irrigation by seepage maintains a constant supply within easy reach of the roots of vines and trees.

The once arid region has become thoroughly moistened. Where till lately the contention for water was keen and ceaseless, one hears now of suits against canals on account of their supersaturation of adjoining vineyards. Nor is this to be wondered at, seeing that in the midst of the once parched plain there are now patches of artificial morass created, as in the Poudre Valley, Colorado, by over-irrigation, and continued for want of drainage. For in Fresno, and Fresno alone, has drainage become a vital question. The largest vineyard in the district, that of Mr. Barton, has not been watered for two years, and the enterprising proprietor has actually ex-

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cavated ditches around his property so as to drain it, to a depth of 6 feet. The Eisen vineyard close by, one of the oldest and best known in the district, is now involved in a suit which its proprietor is bringing in self-defense against the canal proprietors for flooding his land. It is not only excess in flooding that has to be avoided, but excess of seepage, which is just as bad. Not only is the creation of a morass on the surface fatal, but the morass condition below is proportionately injurious. Roots, of course, will not penetrate below the perpetual water line, and thus, if the water rises in the soil the depth from which they draw their nourishment is liable to be greatly diminished.

It has been suggested that if the pipe method of subirrigation were adopted the same pipes might be made available for drainage. If this could be accomplished without materially increasing the cost it should contain a solution of the difficulty in a few cases, but, as a rule, where drainage is needed subirrigation in any season would be superfluous if not injurious. A remarkable evidence of the rate of seepage in sandy soils is notable in the Fresno district, and that is two little ditches, a foot or so apart, each of them carrying a swift stream of water, which is soaking though the bank of a small canal, and which they divert from the field beyond. A few ditches of this description compose the whole of the drainage work yet done in western America. Even here the drainage problem does not appear to threaten the requirement of works any more expensive than those already in use, and, except in localities as peculiarly situated as Fresno, it is improbable that any outlay to provide them will be needed, at all events for many years to come.

CAPILLARY ATTRACTION OF WATER.

For a complete comprehension of these facts, however, it is necessary to read them by the light of a knowledge of a peculiar property possessed by many soils, and which forms a most important factor in all calculations as to the limits of irrigation. It has been found by experiment in California that water rises rapidly in coarse, sandy soils, but only to a moderate height; while in finer soils, whether clayey or of a silty formation, the rise is slower but higher. So that in a few weeks or months, as the case may be, the water attains twice or thrice the height that it climbs to in the former. This has been said to be accomplished by means of a "capillary attraction," in which heat may, perhaps, be an important agent, seeing that the phenomenon is not observed in Colorado to anything like the same extent as in the California slope, and presents the result of experiments made upon different soils to test their capacity in this direction. A consideration of these results points to the superior value in suitable soils of subirrigation, or irrigation by seepage from below, over all methods of surface application, because it is thus possible to avoid caking the soil and loss by evaporation.

EXTENSION OF THE IRRIGATING AREA.

Taking together the facts as to seepage of water from rivers or ditches, and those relating to the rising of water by means of what is calleed capillary attraction, one is furnished with the key to the gradual diminution of the water necessary for irrigation of the same land, which has been noted in almost every part of the West. In Colorado alone, in situations like that of Greeley, upon a deep porous soil, with a rapid fall and quick drainage, as much water is said to be used to-day as in the initiation of the practice of artificial watering twelve years ago. Everywhere else the verdict of experience is that the water goes farther every year.

The ranch-owner, who doubted if his spring or brook would suffice for 20 acres, extends the area of his cultivation bit by bit until it reaches 80 or 100 acres, and he still has some to spare.

Bishop Musser, of Salt Lake, who has made an especial study of irrigation in Utah and abroad, states that when the city was first founded there was only water enough from a particular source for 800 or 900 acres, while now the same amount supplies more than 5,000 acres. In another Mormon settlement, named Bountiful, where at first it was supposed that only a few families could be placed on account of the smallness of the stream of water available for irrigation, there are now between 4,000 and 5,000 people, all maintained by means of the same supply. The whole of Utah has been peopled and all its cultivation based upon little driblets of water in this way. Yet the sandy aridity, which is absolutely worthless without water, may be soon over-wet, and it is found that where a piece of ground is fed by good seepage to irrigate it as well kills the crop. Here, as at Fresno, Riverside, Mussel Slough, and in Tulare County, Cal., maybe seen farms and vineyards up to 160 acres in size irrigated solely by seepage from ditches which run along the upper edges of their fields.

The distance that water will penetrate, even without any discoverable dip in the land, has been partially indicated by experiments in subirrigation, when the pipes and orifices, though 50 feet apart, have saturated the whole soil between them. With

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a fall in the country the seepage extends for far greater distances, and, curiously enough, an instance is reported in the San Joaquin Valley where, upon the construction of a canal, a well a mile or two on the upper side increased several feet in depth after the canal had been some time running.

Another most instructive fact is that as the water supplied diminishes the crops tend to increase. They now raise more grain in Utah with half the water than they did when they concentrated double the supply upon a smaller area. For the first year or so of irrigation the soil becomes soppy, but afterwards, while seeming drier, it is not nearly so thirsty; when it is very shallow flooding ceases and seepage alone is relied upon. Irrigation is said to close the pores of the soil with an infiltration of rich, impalpable silt, so that it absorbs more slowly and retains what is absorbed much longer.

Under good cultivation the soil thus enriched becomes far more fruitful than it originally was; but too much water makes the land cold, and eventually turns it into a quagmire. When soakage, as from flooding, is accompanied by soakage upwards by "capillary attraction," the consequence in California is the formation of what is termed "hard-pan," an impenetrable layer which resists the entrance of roots and yields them no nourishment. Where this is feared flooding is suspended and the subterranean supply depended upon. Such is the rapidity with which roots push for water, even where moisture can be found, 15 or 20 feet from the surface, no flooding is needed after the first year or two. The roots of vines have been known to penetrate nearly 30 feet in a little over three years, while even lucerne roots travel 15 or 20 feet downwards to moisture. But the catalogue of facts, proving in a variety of ways the injurious effects of over-irrigation, and the marvelous results to be accomplished in time by small streams of water, might be multiplied indefinitely.

THE DUTY OF WATER AND ITS CONDITIONS.

A preliminary doubt as to water measurements has to be taken into account, for until recently different standards have been in use; and still there is, even in flourishing districts, the greatest laxity in applying what standards they have. In Los Angeles, for instance, the zanjero, or water-master, has relied solely upon his eye to judge of the stream a farmer was entitled to receive; and though practice no doubt had enabled him to allot something like an equal share to each person concerned, it is plain that any attempt to define the quantity in recognized measures could only be an uncertain approximation. In every State the use of water for mining purposes has preceded or, in the first instance, overshadowed that for irrigation; and, consequently, what estimates have been made in the past have been expressed in "miners' inches." This was supposed to define the quantity of water flowing through an aperture an inch square, but, as in some parts the pressure adopted was that of a 4-inch head, while in other places the head was 6 inches, there was evidently abundant room for variation, even in the determination of the capacity of a single inch. When, again, a number of inches came to be measured at once it became possible either to adopt an aperture 1 inch high and the specified number of inches in length, or to take the square of the whole number of inches as giving the dimensions of the orifice, in which case, again, there was another great cause of variation. The State engineer of Colorado has calculated that the miner's inch in that State has been .026 cubic feet, or, roughly speaking, a fortieth of a cubic foot; and this is now generally adopted as its equivalent, though, as a matter of fact, in more southerly States, where water has been scarce, the miner's inch has only meant one-fiftieth of a cubic foot.

Taking into account this initial cause of confusion in the measurement of water, we next find that the quantity of land which any given unit of water will irrigate is governed, first, by the kind of soil, subsoil, the rain-fall, temperature, and evaporation of the particular area irrigated, next by the kind of crop grown, and the method of watering it, as well as by the length of time which that land or neighboring land has been irrigated, and lastly by its position with regard to seepage, and its capacity of capillary attraction. It is plainly no easy matter, even when all the terms of the special instance are known, to fix the duty of water under these circumstances. But in almost every instance the records of American experience are wanting in respect to one or more particulars, and hence, again, there is only room for the vaguest conclusions.

Instances can be quoted in which a flow of 1 cubic foot per second has supplied 9,000 acres, while in others it only supplies 50 acres. It is vain to attempt to arrive at accuracy in the face of such extremes as these. The manner in which water is sold in the States puts another barrier in the way. A water right there does not mean a right to any given quantity of water, but a right to have a stream of a certain capacity turned into the purchaser's lateral for as often and as long as he pleases. Each farmer accordingly draws upon the supply just according to his fancy in each season. As yet, as there is water in plenty, the Colorado companies do not restrict their customers to the stream they have purchased, but give them whatever flow they happen to have. The

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farmer, for his part, does not measure the quantity he receives nor yet the quantity which flows away from him, so that on neither side is there any opportunity of obtaining exactitude as to the quantity actually absorbed by the land. Where measurements have taken place, as in southern California, it has usually been at the farmer's receiving point, from which there is more or less loss, according to the nature of his soil, the make of his ditch, and the distance to be traveled before the field is reached, which renders these almost equally unreliable.

In the face of this array of disturbing causes it is ut erly impossible to do more than notice a number of rough generalizations, which have some force in special localities. The more sandy the soil the more readily it receives and parts with water, while, as the soil becomes heavier, it absorbs less, and retains it longer; the deeper the soil, the more water is required in the first instance, while with a retentive subsoil succeeding waterings can be greatly diminished. The heavier the rain-fall the greater the duty of water in equal temperatures, and when evaporation comes into play the duty has to be correspondingly reduced. Where the land is in a position to receive seepage from higher irrigations, or is so porous as to draw a sufficient supply from its own laterals, or is so saturated as to need for a time no water even in its canals, which are, perhaps, as at Fresno, turned into drainage-ditches, the duty, of course, tends to become nominally enormous. Then, again, small grains as a rule take twice as much water as corn or potatoes, and many times as much per acre as orchards, which are watered on an economical method. Even the waterings given to one grain, such as wheat, vary according to locality from one to four, oats requiring more and barley a little less. In Riverside the orchards are often only watered once from furrows in winter, and once, twice, or thrice, according to the idea of the owner, in summer. Where flooding takes thousands of gallons the furrow system only requires hundreds, and subirrigation tens of gallons for a similar area, though, of course, under different crops.

COMPARISONS AND CONFLICTS.

Setting aside the question of the actual quantity of water used or needed for navigation, we find that, even comparing the flow of water allotted to farmers for as long as they like, there are the widest differences. Taking the flow of one cubic foot to the second (available during the season for cereals of Colorado, and all the year round for the orchards of California), without making allowance for differing rain-falls, this supplies in Colorado 53 acres; Italy, 70.2 acres (Col. Baird Smith); Utah, San Bernardino, Cal., and France, 80 to 100 acres; San Gabriel, Cal., 120 acres; Fresno, Cal., 160 acres; India, 150 to 200 acres (sira cotton); Los Angeles and Anaheim, Cal., rather over 200 acres; Riverside, Cal., nearly 300 acres; Ontario, Redlands, Cal., Algeria, and parts of India, 400 acres; Sierra Madre, Cal., 580 acres; Spain, as high as 1,000 acres; Pasadena, Cal., 1,665 acres; and by subirrigation, according to one or two experiments, from 1,500 to 9,000 acres.

In Kansas, Arizona, and Mexico the figures given are too conflicting to be quotable. There are the same contrasts as to the depth of water which should be put upon land. In Colorado two or three waterings are given of from 3 to 5 inches in depth; in some parts of southern California waterings of 12 inches in depth have been given, and in other parts a total sufficient in the year to make a depth of several feet. On the other hand, there are farmers in these districts who, according to their own testimony, employ l ss than half the quantity used by their neighbors, and with equal if not superior results.

If the Colorado farmer were to use all the water at his disposal, he would cover his fields nearly 4 feet deep. The practice appears to be, on the average, to use about one-fourth of this, but there is such a difference in soils that this is but a poor guide. Where a coarse sandy soil, with porous subsoil, can take 10 feet in the season, a fine compact alluvial, with clay subsoil, would be injured with 1 foot; hence, 10 acres of the latter can be irrigated to one of the former by the same quantity of water. A natural measure of the duty of water in many places may be supplied by the rain-fall of good harvest years, making allowance for the time of fall. In central California 13 inches during a frostless winter and spring have proved sufficient, and probably if 12 inches could be secured from rain-fall and ditch together during the spring it would prove more than ample for flooding cereals.

THE COST OF WATER—THE PRICES PAID.

The prices paid for water are so complicated by the conditions under which it is sold that it is almost impossible to do more than quote the rates in different localities. The water itself costs the appropriators nothing beyond the expense of putting it upon the land, which differs, of course, in every State and every district. This first outlay for works furnishes one clue of an uncertain character to the price of water. Where farmers unite for the purpose of securing a joint supply, they work or pay their share

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of the construction, and afterwards their proportion of the sum necessary to keep the works in repair, so that it is difficult in many instances to determine exactly what their water costs them. In Colorado it is considered that an irrigable area should be supplied with an outlay upon main works of £1 or 25*s.* per acre, an estimate which appears to agree, on the whole, with experience elsewhere.

Occasionally, as in Kansas, where very large canals run through very favorably situated country, main works of a temporary character can be built for as low as 10*s.* per acre, while on the other hand, where special difficulties intervene, as at Salt Lake, in the price to be paid for easements over private lands one finds the canal costing 50*s.* per acre to build. This is by no means the maximum of first expenditure.

With extra works, such as fluming or tunneling, as in Colorado, or wooden channeling, as in the city ditch at Salt Lake, Utah, or expensive piping, as at Pasadena, or the Highlands Canal in Los Angeles County, Cal., the cost may rise, as in the last two instances, to £8 and £10 12*s.* per acre. Here, of course, the supply is for small areas under intense culture. The greater the scale of the undertaking the less the cost per acre.

The 150,000 acres at Bakerfield, Cal., can be watered by one proprietary for 10*s.* 8*d.* per acre, whereas, if divided into a number of different schemes, adapted here and there to the condition of ownership rather than to the natural surface of the land, it would probably have cost twice as much. Or, take the 76 canal beyond Fresno, Cal., which now supplies only 20,000 acres, at a first cost of about 25*s.* per acre; with an extension of its secondary canals, so as to allow it to supply the 40,000 acres lying under them, the outlay per acre would be reduced to 20*s.*; while if the complete plan, which is for the irrigation of 180,000 acres, were carried out, this would be still further brought down to 15*s.* per acre. Water, therefore, is dearest where the schemes are smallest; that is, where the works are relatively most costly.

The same fact is again illustrated by the price asked for water-rights, which are almost invariably highest in small schemes. Thus, in such "colonies" as Ontario, Etiwanda, or Pomona, Cal., where land is sold in 10-acre blocks, a water-right costs from £15 to £20 per acre, while upon 80 acre blocks it can be purchased in Colorado for £3, in Utah for about 50*s.* and in Kansas for half that sum. Having a water-right, the farmer is then liable only to a yearly assessment for maintenance. This, on the other hand, is highest as a rule where the water-right is cheapest, ranging from 8*s.* per acre in Kansas, and 4*s.* an acre in Utah, to 2*s.* 6*d.* in Fresno, and 2*s.* in several colonies in Los Angeles County.

In Colorado the maximum rate of 6*s.* per acre per annum is rarely charged, the water-right owners only paying the 6*d.* or 9*d.* per acre, which is actually spent on repairs, and the same custom prevails in some parts of Utah; but in both of these instances the schemes are large.

The prices of water-rights vary from a variety of causes, such as whether the water-owner has land of his own to sell or not, so that particular instances offer but little guide to an exact estimate of their value; nor do they furnish any clew to the quantity of water actually sold.

In Kansas water is paid for according to the acreage of the purchaser, who takes as much as he likes in return for his yearly rental. This most wasteful of practices was tried and abandoned in southern California, as it will be abandoned in Kansas when water becomes more valuable. Meanwhile its steady increase in price is everywhere noticeable. Thus, at the foundation of Greeley, Colo., 80 acres with water could be purchased for £60; a few years later the water alone became worth £100; to-day the same watering right is bring £200, and with the land is worth £600. In all the "colonies" of California there has been as great a rise in the price of water, though there it is to be found in almost every instance linked to the land. This puts another difficulty in the way of estimating the exact price of water, for though the water is really that for which the money is paid some deduction has to be made for the area upon which it is to be utilized.

Land which in the arid state brings only £1 per acre, is sold at £10 or £15 per acre when under a ditch, and something like this proportion is maintained even for higher priced dry lands, which rise from £5 to £40, and from £15 to £100, when artificially watered.

When the land and the water-right are sold apart the canal-owner makes two profits, one in the tripling or quadrupling of the price paid for the land, which is his chief profit, and the other upon the water-right, the price of which represents his outlay upon works, with liberal interest added. The first profit, made nominally upon the land, which is often greater than here stated, is, of course, really another profit upon the water, and as the cost per acre of the works is, as a rule, less than the cost per acre of the land, the gain upon the investment in water is much larger than appears. Where there is no sale of land, that is, where the water has been brought to land already sold, or for sale by persons other than the canal-owners, the price of the water is much higher, reaching sometimes as much as 20*s.* or 25*s.* per acre per annum. At Los Angeles, Cal., water is sold by what is called a "head," which under their loose measurement varies from 2

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cubic feet to 4 cubic feet per second, at 8*s.* per day or 6*s.* per night in summer within the city, twice that price outside of its boundaries, and half the price in winter.

At Orange and its neighboring settlements the price for a flow of about 2 cubic feet per second is 10*s.* for twenty-four hours, or 6*s.* per day and 4*s.* per night, and in winter 6*s.* for the twenty-four hours. At Riverside the cost is about 7*s.* 6*d.* per day, or 5*s.* per night, for a cubic foot per second, or 12*s.* for the twenty-four hours. These prices, varying indefinitely as the conditions of sale vary, furnish but an insecure basis for any generalization.

Possibly a better idea of the importance of water than can be derived from any list of purchases and rentals in particular places may be obtained by a glance at its capital value. It has been calculated that the flow of a cubic foot per second for the irrigating season of all future years is worth from £15 to £25 per acre in grain or grazing country to £30 in fruit lands. This is the price paid to apply such a stream to a special piece of land for as long as the farmer may think necessary, the knowledge that an excess of water will ruin his crops being the only limit. But if a flow of a cubic foot per second were brought in perpetuity without any limit as to the acreage to which it might be applied, or the time or circumstances of applying it, the capital value of such a stream in southern California to-day would be at least £8,000.

PRODUCTS AND THE WATER PRICE.

What price can be paid for water, or land and water together, depends upon the products raised and the price of those products at the homestead, by taking which as a guide consideration of complicated questions as to markets and freights may be avoided. So far as American experience goes there appears to be no limit to the scope of irrigation, which embraces the fruits and cereals of the temperate zone, as well as the products that are raised only under a tropical sun. Apples, blackberries, and barley are irrigated in Colorado or northern California, as are the rice, cotton, and sugar in the hot lowlands of Mexico. Over a large area of the West it may almost be said that as nothing can be grown without irrigation anything can be grown by irrigation.

Wherever water has been plentiful and the ground fairly level it has paid to grow irrigated grain. There are thousands of acres in Colorado and Utah which have never grown any other crop, and are still growing it. The irrigated area under grain in Mexico is very large and the yield heavy, while it is a moderate estimate that in the States 5,000,000 bushels of wheat are raised by its means.

It is generally calculated that grain can be grown at a profit under irrigation for 2*s.* 6*d.* per bushel, and even where, as in Arizona, the crop has to be teamed 12 or 14 miles across the desert at a cost of 7*d.* per bushel to railways, upon which the rating is all against the local grower, grain is found to pay. Of course the chief prosperity in the wheat districts was when 4*s.* and 5*s.* a bushel were regularly realized and a profit of at least 50*s.* per acre was counted upon. All this has changed since the fall in prices, which has brought profits down to 20*s.* per acre, with a yield of 25 bushels. Grain pays still, but very poorly, and even in better times it is generally considered the poorest paying crop that can be raised. Still it does pay for irrigation, and this is an important fact to the farmer who can not afford to wait for the higher returns from intense culture. Nor does grain-growing noticeably impoverish the land where proper precautions are taken against the washing out of the fertilizing matter in the soil and for the utilization of any sediment there may be in the irrigating water.

In Utah a rotation of crops is adopted; but in Colorado are to be found instances where grain has been grown every season for ten or fifteen years without perceptibly injuring the land. In Arizona and Mexico the native population have raised their wheat and Indian corn from the same plots for scores, if not for hundreds, of years, and to them the idea of manuring is quite unknown. Here and there a farmer may be found who takes the pains to use the droppings of his stock upon his fields, but this is the exception. As a practice systematic fertilization is unthought of, and so far no serious injury appears to have resulted from its neglect where any falling off in yield has been followed by change of crop. This is of interest as showing at all events that the need of expensive restoration of the soil is not likely to assert itself in our richer lands until after some or perhaps many years of irrigation. Neither does the grain itself suffer if the seed be carefully selected. In southern California irrigated wheat has a slightly thicker skin, makes more bran, and to the practiced eye is slightly darker in hue than that from the wet northern region, but it is said even there to be fully equal in quality to unirrigated wheat, a testimony which was repeated by millers in Mexico, Arizona, and Colorado. It is not from any such fallacious anticipations that grain-growing by irrigation is condemned in the States. Though all kinds of grain can be grown well and at a profit, the growing is considered a mistake, because the profit is too small. Land and water that will grow grain will yield crops which are much more remunerative. Grain may be taken in rotation with potatoes, which flourish under irrigation in a sandy loam, or with peas or lucern, which act as restoratives to the soil.

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All kinds of root crops and all kinds of vegetables can be grown, and are grown, usually at a somewhat higher profit than grain. These again have as a rule a smaller profit than can be obtained from stock, which, in its turn, yields to the profits derivable from grapes and fruit.

STOCK-RAISING ON IRRIGATED LAND.

It is a more remunerative occupation to grow beef and mutton or bacon, for which there is just as steady a demand. Two-thirds of the 50,000 acres irrigated at Phœnix is under grain, but this little valley also raises its 100,000 hogs. Dairy produce is successfully raised in northern California by means of irrigation, where, indeed, it is applied to little else on account of the regular and sufficient rain-fall which can there be counted upon. Even in Australia many towns owe a considerable proportion of their vegetable supply to the Chinese irrigator. It would be a mistake to ignore these minor ways in which irrigation can be very profitably employed, especially in the neighborhood of centers of population, but it would be an equally great mistake to suppose that irrigation is only practiced on this scale. A prevailing misconception as to irrigation is that it is employed only for small areas under high culture. The fact that great stock-growers in California, such as Messrs. Haggin & Carr, or Messrs. Miller & Lux, irrigate thousands of acres for stock purposes appears to be lost sight of. Much Mexican irrigation is carried on upon the same plan. Where the great land-owners have their immense estates one can see not hundreds but thousands of acres artificially watered; and where smaller proprietors enjoy a share of the coveted irrigable area they cultivate so closely to each other's borders that the fenceless area as far as the eye can reach appears one gigantic irrigated field. The great valleys of the Ortiz, the Concho, the Florido, and the Nazas, the wide sloping plains of the Laguna country in the neighborhood of Lerdo, and in the province of Leon, exhibit the patient industry of the peasants and a marvelous fertility secured by means of an artificial water supply of the rudest character. On the great cattle and sheep ranches of New Mexico the proprietors, some of them Australians, are enlisting the same invaluable ally in order to protect themselves against the occasional ravages made in their flocks and herds by bad seasons. It pays as a rule to irrigate natural grasses, for by this means the carrying capacity of land is increased 33 per cent. The Chowchilla Canal, in Fresno County, Cal., 30 miles long, 30 feet wide at its mouth, and 2½ feet deep, is used almost solely for this purpose, and there are 20,000 acres of natural-grass land irrigated in one property in Kern County.

THE VALUE OF ALFALFA.

But the mainstay of the American stock farmer, large and small, is lucern, there styled alfalfa, which, though unsuccessful in England, is highly prized in France. In every Western State this is grown to profusion. There are 35,000 acres of it grown by irrigation at Bakersfield. In Yolo County, Cal., almost the whole of the 13,000 acres watered from the Woodland Canal is under lucern; it is to be found upon almost every colony plot in southern California, and is the surest source of revenue in Utah and New Mexico. The area planted with this crop is increasing with marvelous rapidity. It is said to carry 10 sheep or even 20 sheep to the acre if it be cut for them. It is not a new growth in Victoria, but without irrigation its marvelous qualities have only partially developed themselves. At Dookie, with only the natural rain-fall, it can be cut but once a year, yielding about three-quarters of a ton to the acre; while at Bacchus Marsh, with irrigation or water within reach of its roots, it can be cut five or six times, yielding 7 or 8 tons, and lasts fifteen to twenty years.

There are some 300 acres of it in this locality, thriving upon a natural seepage, and though rather delicate in its earlier stages, owing to the lack of irrigation, when once firmly rooted it raises the value of the land to from £50 to £75 per acre. It is sown broadcast and freely, and with a little wheat, oats, or barley mixed in it; is rarely manured, though better for an occasional scarifying and top dressing; is never fed down, but cut early and often, and found to possess splendid fattenimg qualities. Under irrigation lucern seems to flourish everywhere, particularly in sandy loam and in a warm climate free from frost, and though the yields given vary they are all great. Three cuttings are sometimes obtained in the first year, making a total crop of 4 tons to the acre but the general thing is, as in Utah, to obtain only one crop in this period. After this 6 tons are expected in the second year, and 8 to 12 tons in the third year. There are poor soils where it is cut only twice or three times, and other soils on which its quality does not keep pace with the quantity, but on those that most resemble our own plains the cutting is rarely less than four times, and the yield generally over 10 tons per acre in the course of the year.

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FRUIT-RAISING BY IRRIGATION.

But the products for which irrigation is most necessary, and in which it yields the largest, are grapes and fruit. The great land-owner in America not only plants his thousands of acres of lucern and perhaps his ten thousand acres of grain, but, with incessant enterprise, plants his hundreds of acres of vines and fruit-trees. When irrigation is employed, however, the production is almost wholly in the hands of small proprietors, men often of some education and some capital, who have found an attractive field for the exercise of their intelligence in bringing small allotments into a condition of the highest productiveness. Judging by the results obtained in southern California, to which this class of cultivation is as yet chiefly confined, it has not proved an unprofitable speculation. It is safe to predict that in a short time grain-growing will be given up on all small areas of irrigation and that a commencement will have been made upon the larger tracts to follow the same example. It pays better to grow fresh vegetables for towns or can them for export, or to establish chicken farms or bee ranches than to raise grain for export. Already in northern California the great farms, so famous a few years ago for their yields and extent, are being cut up into vineyards and orchards, and where along the old mining ditches any vintage ground can be secured it is being put to the same uses.

Twenty acres under vines or fruit-trees are preferred to 160 acres under grain. There is more regular employment and more regular leisure, with less stress at a particular season for adult male labor. An acre in raisins was reckoned as valuable as 5 acres of wheat, when the price of wheat was nearly twice what it is now.

The fruits grown are oranges, lemons, limes, apricots, pears, figs, peaches, pomegranates, nectarines, apples, plums, quinces, cherries, olives, almonds, walnuts, and chestnuts. From some of these two crops a year are obtained, but of course none of them bear for some time after planting. This is not all lost time to the American farmer, who grows great crops of vegetables between his fruit trees until they are ready for bearing. The period during which no return is expected, even under irrigation, is considerable; as, for instance, it is for peaches, apricots, almonds, and vines, four years; for oranges, ten years from the seed, five years from the bud; olives, from seven to ten years, unless the Spanish practice of planting branches is followed, in which case it takes only two years; and walnuts seven years. When the profits do come, however, they are proportionately large.

Nearly 50 per cent. of the fruit grown in California is canned, but only 5 per cent. is dried. The production is increasing enormously every year. Vineyards are utilized not only for the supply of grapes but of raisins and wine; and there is no branch of production into which capitalists and small farmers are now entering upon a greater scale or with more confidence than wine-growing. The clearest heads in California consider the overproduction of wines or raisins an impossibility, and experience is teaching them that at existing prices the investment is remunerative, although wine-making is developed in the face of a prejudice quite as unreasoning as that which has till lately faced colonial vintages. For other fruits, though drying is occasionally adopted, the chief reliance is upon the canning process practiced in every fruit-growing center. The taste for fruit, whether fresh, dried, or canned, is one that appears to grow by what it feeds on, for the demand in America seems to increase almost as fast as production. The markets of the East are, of course, open to the irrigating West, but rates of transports are relatively high, and competion from the West Indies and the Mediterranean is keen, so that it can scarcely be said to be a home market in the ordinary sense of the term.

The injurious effects of overirrigation are just as potent in fruit-growing as in every other crop. It is claimed on the authority of a commission of experts, appointed by the French Government to inquire into the remedies for phylloxera, that regular furrow irrigation in summer keeps the disease in check, but it has been proven in Fresno that an excess of water injures both the wine and raisin qualities of the grape. There is a special disease to which orange trees are subject which strips the tree of its leaves, prevents the fruit from coming to maturity, and finally kills the tree, which a special committee of the Southern California Horticultural Society, after an exhaustive inquiry, has declared to be wholly due to overirrigation and deficient cultivation. The citrus family can endure more water than any other class of fruit-tree, but it is clear that the limit of the water consumption of any of them is soon reached, and that to go beyond it is injurious if not fatal.

PROSPECTS OF IRRIGATION IN AMERICA.

We have now taken a rapid glance at the products of 2,500,000 acres of Western America, watered by 12,000 miles of main canals and 120,000 miles of subsidiary ditches, at an expense of many hundreds of millions of dollars. The estimates of the value of the yield from irrigated vineyards and orchards are not official, but those engaged in supplying the markets put the production of California vineyards this year at £1,000,000 and of the orangeries and orchards of the same State at half as much again.

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A good deal of fruit is grown for home consumption in neighboring irrigating States, but prohibitive railway rates have prevented the full expansion of this and other classes of production. Utah and Colorado, entirely dependent upon irrigation, draw their revenue from other classes of products—the latter, in 1883, raising in value £1,100,000 of grain and root crops, the former £700,000. To assess the total value of the products raised by means of irrigation, many of which could not be raised without it, would be no easy undertaking; but it is quite clear from the statistics that it must be expressed in millions sterling. Adding the enhanced stock-bearing capacity of the country, and the value of industries not directly productive, which are dependent upon the irrigating settlements, would make up a grand total that would probably surprise the Americans themselves. There is no reason to suppose that the list of products capable of being profitably grown under irrigation is yet exhausted. Experiments are continually being made with fresh crops, and the result is generally favorable where climate and soil conditions are studied. Great as the produce of the artificially-watered West now is, the prospects are that it will become very much greater; and the opinion of those qualified to form a judgment is that irrigation, marked as have been its successes, is yet in its infancy, and has given no more than a promise of what it is destined to achieve.

HEALTHFULNESS OF IRRIGATED LANDS.

There are irrigated lands in which health seems entirely unaffected; there are others where the influence of malaria is but too patent, and the task is to discriminate between them. The river bottoms, as they are termed, flats, but little raised above the level of streams, are, throughout the southern parts of the United States, recognized as malarious whether irrigation is practiced or not. Fever, ague, and chills are prevalent in such localities in Missouri, in Louisiana, as in the southwestern area. From their position these lands are easily irrigable, and hence settlers are tempted upon them and become subject to the same complaints. Whether irrigation, as is probable, increases the danger in such spots is not known, but in places similarly situated, though not malarious previous to irrigation, it seems that the practice has acted injuriously. Where the soil is saturated and artificial morasses are formed, as at Fresno, fever is naturally found in the immediate neighborhood. Along the lower lines of this district the miasma rises to a height of 10 feet, and here, as in the counties further south, the sleeping-rooms are always placed in a second story in consequence. Much of this region was malarious before irrigation was practiced, and in parts the formation of channels is said to have actually reduced the danger. This, however, in such circumstances, can only be entirely removed by complete drainage. Much importance is attached to the source of the water drank, and wells are sunk to great depths so as to avoid all seepage and secure a pure supply.

On the bench or mesa lands of California or Kansas, in those of Colorado, with their rapid natural drainage, or in the porous lands of Arizona and New Mexico, malaria is as yet unknown; nor does there seem much prospect of its appearing. It is feared only in lands naturally swampy, or readily made so. It is not regarded as a fatal complaint, though the repeated attacks to which its victims are subject necessarily have a permanently weakening and depressing effect. There are many who seem to escape even in these localities, but there are others whose sallow and sickly looks only too plainly indicate the presence of malaria.

UNITY OF LAND AND WATER.

Another matter arising out of American experiences which it is desirable to notice is the relation between the ownership of land and that of water. Where a farmer has his own canal to his own land no question arises. Where a number of farmers excavate a ditch and parcel the water out between them, the only question is as to whether the water used by each can be applied where he pleases, or whether it must be applied to particular acres specified in the contract. If he can sell his water to another or turn it upon new land, the business of the company becomes more complicated and the value of the lands first irrigated is not so well maintained. If, however, as is often the case, the farmers have been unable to make the ditch without assistance and have called in a capitalist to join them, he frequently arranges to take up a certain amount of unoccupied land which can be served by the canal and from the sale of which he looks to derive a considerable share of his profit. To prevent competition, therefore, he generally stipulates that the water rights which the farmers receive in return for their investment of labor or capital shall attach to their particular acreage and can not be transferred to any other land. By this means he secures for himself the market for all irrigated land outside of these acreages. When he sells what land can be irrigated by his share of the water his interest in the canal determines, and the works become the property of those who own the various ear-marked acreages which it is confined to supplying, unless by common consent the proprietors then decree otherwise.

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Capitalists often construct canals into unoccupied country as a speculation, and sell so much land with a right to so much water attached until rights covering the whole flow of the canal are parted with, and the new owners of the land become joint proprietors of the work which feeds it. In this way land and water are bought and sold together, the area of the land being measured by the quantity of water; for in the West all value may be said to inhere in the water. Land is plentiful and almost worthless. The owner of the water really owns the land, for it is useless without his supply. The quantity of available water, and not the area of a territory, defines its agricultural extent; consequently where capitalists have built canals to lands which they do not own and have secured the water they have really acquired the land too. They have the farmers absolutely at their mercy, and enjoy a monopoly of a most arbitrary kind. A land-owner who obtains a water-right can carry a stream to his own property at a distance through land as good as his which never can be cultivated except with his consent, and which will fetch only one-tenth of what his irrigated land will fetch, though the two are only divided by a fence.

A recognition of the danger of allowing water to be monopolized without regard to the land has led a commission appointed to inquire into Californian irrigation to declare that, "as a matter of public policy it is desirable that the land and water be joined never to be cut asunder; that the farmers would enjoy in perpetuity the use of the water necessary for the irrigation of their respective lands; that when the land is sold the right to water shall also be sold with it, and that neither shall be sold separately." Major Powell, in his careful draft of a land system adapted to the arid region, most emphatically recommends that "The right to use water should inhere in the land to be irrigated, and water-rights should go with land titles." In Colorado the feeling has gone so far that a proposal has been made in the legislature to compel all canal owners to supply any persons with water which they are not themselves using, at fixed rates; but as this would simply mean transferring to land owners who had invested nothing in canals part of the profit to be made by those who had so invested, the proposal was not entertained. Indeed, where the companies, as at Denver, sell the water-right with the land, and then contract to maintain a water supply in perpetuity for a fixed sum per annum, the system is unobjectionable, providing that, as in these cases, the water-right has been properly obtained.

In Colorado and Utah, notwithstanding their peculiar situation, the water is given to the first applicant, though he has to purchase the land to use it upon, which without the water would be worthless. It would have been more economical and more simple to have sold the water and given the land. Be this as it may it is essential that they should always go together. The practice of tying water-rights to the land has another argument besides that of avoiding monopoly, and this is that it tends to a more careful use of the water by its concentration upon a smaller area.

THE COLONY SYSTEM.

At first, as at Greeley, colonies were established upon something of a communal basis beyond the joint ownership of water-works, but this is now very rare. It is still frequently the case to find them organized upon a temperance basis, or by the union of those of the same nationality, as in the Scandinavian and German colonies. The joint interest in the sources of their irrigation supply remain, but all other kind of community has disappeared. Under the most favorable plan a piece of irrigable land is marked out into small holdings; either the land owner or a company construct works to supply these with water, and the lots are then sold to any purchaser with water-rights attached. By liberal advertising and easy terms of sale new centers of population and production are created in this way in a very short time, so that the barren plain in the course of a few years becomes dotted over with these oases until one joins another, and at last they inclose and support a thriving and well-built city, such as Fresno is to-day. Altogether there are some fifty of these colonies in California, some of them planned upon a large scale, such as Riverside, and containing their township within themselves. It becomes the interest of the original owners to make the advantages which their lands offer widely known, and, consequently, they turn themselves into emigration agents of the most energetic kind. The Eastern States are deluged with pamphlets; even the Old World is reached by means of the printing-office and by correspondence through the relations of those already settled. The aim is to make the place attractive, and no expense is spared to insure success. In one such enterprise at Ontario the proprietors have laid out nearly £100,000 upon 8,000 acres of land, bought at 28*s.* per acre; of this sum about £10,000 was spent upon head-works for the water supply, which is conducted in 26½ miles of cement pipes to the corner of each 10-acre allotment, and in 3½ miles of iron pipes to the township for domestic purposes, at a cost of over £10,000. More than £20,000 in land was given to establish an agricultural college now built in the center of the settlement, nearly £4,000 spent in planting trees and making streets, and £700 in securing a railway station. There is a double avenue running through the colony 7

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miles long in a straight line and 200 feet wide, planted with eucalyptus trees, and intended to contain a cable tramway, and from the masts of which will be suspended electric lights, run by hydraulic power. Over £7,000 was spent in advertising this colony, and the result is confidently awaited. Many persons, weary of city life, are drawn from the New England States, while numbers are attracted from the Old World by the inducements held out to them.

The colony enterprise has many advantages for those who engage in it. To join in it does not imply so great a trial as that of facing the wilderness with no neighbor less than miles away. It permits of society, of the establishment of schools, churches, and libraries, and the enjoyment of comforts which can not be secured in isolation. It furnishes, in fine, a frame-work for commercial organization and the beginning of local government. It appeals, too, to a larger class than that usually drawn to agriculture. The physical labor required is not so severe; there is more scope for intelligence, and it offers remunerative employment for a small capital.

SMALL HOLDINGS UNDER INTENSE CULTURE.

This is due not to the colony organization, but to the fact that by means of irrigation small holdings under intense culture are proved to be profitable. The land and water which will produce 25 to 35 bushels of wheat at 2*s.* 6*d.* per bushel will produce, under fruit trees, a crop worth twenty or thirty times as much. One-twentieth or one-thirtieth of the area under fruit instead of grain will yield as great a return and a larger percentage of profit. It has been found in parts of Europe where the water is the property of one owner and the land of many others that the tendency of irrigation is to establish a monopoly in land. This is the case whenever the water is not attached to the land, and owing to a defective code lawsuits are frequent. But where water is attached to land and rights are indisputable there is exactly the opposite tendency—to cut up the land into small farms. It needs both men and money to prepare and plant 20 acres of fruit trees at once. It is as much as a hard-working man can do to attend to 20 acres of oranges or 25 acres of vines himself, and then he needs light assistance in the picking season. It is calculated that he can by frugality maintain himself and family upon half as much. Hence in the colonies 40 acres is a large estate; it requires hired labor and yields a considerable revenue.

Whether colony life yields large profits or not, the visible evidences are all of prosperity. The little holdings are neatly tilled, with an air of perfect security, owing to their being often unfenced or fenced only by a row of trees; the houses are neat, well finished, well furnished, and of some architectural pretensions; the people are comfortably dressed and well nourished, and their cattle in capital condition. Many of them brought their savings with them, and they are apparently content with their investment. The poorest places in these colonies have a far greater air of comfort than grain farms of 200 or 300 acres in extent. Whole colonies have been settled direct from Europe by a peasantry trained to the most frugal and industrious habits, and with these success is immediate. The much more extravagant American has a harder time of it if he starts upon his 10 acres with less than £500, as he must maintain himself by laboring for others the greater part of his first three or four years. Still there are numbers who enter upon their little plots without even the money to pay for them or build a house or buy their tools. Many of these are dependent upon advances from the land companies, and, though interest is charged, the general result is that in a few years the hardy colonist has his homestead clear and a profit from it which in a few years more suffices to maintain him and employ him always upon his own land. Ten-acre blocks are gaining in favor in some districts, and nowhere can one observe deserted colonies, or parts of a colony, which show signs of the total failure of effort.

WHAT HAS BEEN ACCOMPLISHED UPON SMALL HOLDINGS.

The success of small settlements in Utah is evidence of what can be accomplished in the face of the greatest difficulties. The tide of immigration constantly pouring into Salt Lake City consists of families often entirely destitute, and who have, as a rule, to become indebted to the Church for their start. They have nothing but small plots of bare land, barren by nature, and are obliged from the very start to yield tithes yearly of all they produce; to give their labor to make the ditch which brings them water, and buy back their debts to the Church with interest. Yet these peasants are enabled to makes homes for themselves which, though plain, are not uncomfortable, and to steadily improve their credit, though trading at the store established in the Church interest, which is not obliged to offer the lowest prices.

With these lessons in the value of intense culture it is not surprising that the most intelligent and most enterprising irrigators desert grain-growing for either stock-raising or fruit-growing as quickly as possible, nor that the newspapers and author-

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ities of weight are persistently bringing before the eyes of others the relatively unprofitable character of wheat-growing, and urging them to attempt higher culture, for its increase means the increase of population and of natural wealth. Railway accountants in California calculate that an acre in vines gives as much freight as 9 acres of grain. A 640-acre grain farm can be managed by a farmer with two grown-up sons, except in harvest time, and at all other seasons the broad, bare fields and rude homestead are not indicative of permanent improvements.

On the Barton vineyard at Fresno, which has 540 acres under vines, thirty men are employed all the year round, without pickers. The winery, which is to receive the 600,000 gallons upon which the proprietor calculates, is a great building, 330 feet long by 96 feet wide, besides which there is a distillery and office in addition to the usual farm buildings surrounding a handsome residence and garden. The capital invested is £60,000, and the amount spent annually upon the 330,000 vines nearly £5,000. Thus under intense culture the same area as the grain farm is made to produce a hundred-fold. With 640 acres under grain a farmer's position is precarious without irrigation and but poorly profitable with it. Under fruit or vines it is a great estate and its owner a wealthy man. The Barton vines are used to produce wine, while on small holdings they are usually employed to make raisins. It is calculated that the value of the products of Riverside will in the course of a few years be £200,000 per annum, and, though the oldest, it is not the best managed colony in California.

IN THE NILE VALLEY.

[This description of Egyptian irrigation is summarized in the main from a report made to the colonial government of Victoria, Australia, in 1887, by the Hon. Alfred Deakin.]

The cultivated area of Egypt is comprised within the Valley of the Nile and its Delta, and are the entire creation of that river, built up by its deposits during many cycles of time. "Aristotle plainly affirmeth the region of Egypt (which we esteem the ancientest nation of the world) was a mere gained ground, and that by the settling of mud and limous matter brought down by the river Nilus, that which was at first a continued sea was raised at last into a firm and habitable country."* Outside of the valley stretches the veritable Sahara, with but here and there, amidst its endless desolation, the relief of a cluster of palms and perhaps a little pasture. Even these oases are fed by subterranean channels supplied from the same source, and their extent altogether is comparatively insignificant. The Egypt of the past was five times as large as the Egypt of the present, but both have been virtually defined by the limits of the river's overflow, which has greatly contracted since a natural dam, whose site is now marked by the first cataract, was swept away. Political Egypt is two-thirds as large as Russia, the largest territory in Europe, but peopled and productive Egypt is only the size of its smallest territory, Belgium, and, so defined, is the narrowest country in the world. It consists of the Valley of the Nile, 550 miles long, and varying in width from 14 to 32 miles, but with an arable breadth nowhere exceeding 9 miles, until it reaches the Delta at Cairo, from whence it expands in fan-shape to a width of 160 miles at the Mediterranean. The depth of the soil of the Delta, which has all been deposited by the river, commencing sometimes below the level of the sea, averages 33 to 38 feet, with a maximum of 50 feet near Kalvûb. It is estimated to be increasing in width and depth of deposit per century average between 4 and 5 inches.

There are some springs of considerable flow, and a few lakes still used for storage, but the Nile itself is practically the sole source of the water supply. According to the estimate of M. Linant—which is probably too high—the discharge at the mouth averages 3,500,000 of cubic feet per minute at Low Nile, and 17,500,000 of cubic

* Sir Thomas Browne's "Pendodoxia Epidemica."

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feet at High Nile. The current at Low Nile averages 2 miles, and at High Nile 3 miles an hour. A further approximate estimate is that one-third of the river overflows at High Nile. This is utilized in two ways. In Upper Egypt, except under the Ibrahimieh Canal, the primitive system is still pursued. The country is divided by embankments into a succession of great basins from 8,000 to 40,000 acres in extent. Sir Colin Moncrief says (1884):

> As the Nile rises in August, these basins fill to a depth of several feet. The water lies in them till October, depositing its fertilizing mud. It is then drawn off, the land is plowed and sown, and a crop of wheat or beans obtained the following March or April. This system allows of only one crop a year, and valuable sub-tropical plants like sugar-cane and cotton can not be grown.

But in Lower Egypt, and in the lands under the Ibrahimieh Canal in Upper Egypt, where the old system has been supplemented by the modern ones of weirs, reservoirs, and permanently-flowing canals, the supply flows throughout the year, to permit of the cultivation of rice, sugar-cane, and cotton. The lands of Lower Egypt are, therefore, perpetually under cultivation, and there is no time to flood the fallow fields in the manner practiced in Upper Egypt. In the Delta there are three seasons of four months each: summer, from April to July, when the estimated discharge of the river ranges from 720,000 to 1,500,000 cubic feet per minute; the flood season, from August to November, with a discharge of from 11,220,000 to 23,160,000 cubic feet per minute; and winter, with a discharge of 1,500,000 to 3,300,000 cubic feet per minute. Each of these seasons has its crops and appropriate methods of cultivation. Yet the Nile is somewhat capricious in its gifts, and does not bestow them with that scientific precision required to permit of permanent irrigation in all seasons of all years. In Lower Egypt it is for three months too high, and for nine months too low. A project has been broached by which the Wadi Raïan, suspected of being the site of the Lake Moeris, which, according to Herodotus, Strabo, and Diodorus, added so immensely to the prosperity of ancient Egypt, should be converted into a reservoir half as large again as the Lake of Geneva, covering nearly 400 square miles, and containing more than 1,000,000,000,000 cubic feet. Until this stupendous work be undertaken, says Cope Whitehouse, Egypt must continue to depend upon an unregulated Nile, and can not hope to materially enlarge its irrigated area.

There are altogether about 6,000,000 acres under cultivation, that is, under irrigation, for in Egypt the words are synonymous. The Delta contains 5,000,000 acres commanded by works, of which about 2,625,000 are actually irrigated, and 840,000 acres more are fit for irrigation, while the balance consists of morass and desert which could only be watered advantageously after considerable expenditure. As during the inundation the water is above the level of the cultivated land, irrigation is rendered easy. The perennial canals, which are employed at Low Nile as well, are of varying size and depth, the larger carrying 3 feet deep of water in summer, and 20 feet in flood season. They leave the river at from 3 to 5 feet below mean low-water level, and, in the upper valley, at about 28 feet below ground level, gradually decreasing in depth until they run out on the surface. In 1873 there were 1,917 miles of navigable, and 6,583 miles of unnavigable canals. Some of the former are of considerable size, the Ibrahimieh, for instance, being 93 miles in length, with a width at ground-level of 230 feet for the first 38 miles, and of 161 feet afterwards, giving a net discharge of about 16,380 cubic feet per minute in summer,

and of 70,140 cubic feet per minute for 100 days in time of flood. The Nahran Canal is 167 miles, and the Yusufi overflow channel 166 miles in length. Most of the works were built under Mehemet Ali, by the forced labor of the Fellâhin, and consequently their true cost can not be determined. The annual state outlay upon their maintenance amounts to about 2 shillings an acre commanded. There is, in addition to this, the *corvée*, or compulsory labor, required from the villagers, which was equivalent in 1884 to an army of 165,000 men working for 100 days, and in 1885 to an army of 117,700 men working for an equal period. This practice is being gradually abolished.

The water is diverted from perennial canals by permanent or temporary dams through simple cuts in the bank. The former are composed of masonry piers 8 feet thick, with openings 15 feet wide, closed by timber beams set vertically, supported by the masonry in the bed of the canal, and above by a cross-beam placed from pier to pier. They are often surmounted by arches, thus forming a bridge on the same structure. When the watering is over the beams are lifted, and the stream passes on to the next dam. The temporary work is of earth, occasionally a little strengthened with piles. There is a little furrow irrigation in orchards and gardens, such as those of the Khedive, at Gezireh, where, by simply fitting a flower-pot laid upon its side with its mouth up-stream into little channels, the flow was delayed so as to permit of sufficient soakage into the soil to supply the trees, while the surplus water passed through the small aperture at the bottom until stopped by another flower-pot. But, as a rule, all watering is managed by submersion, the fields being readily divided into plots, by ridges made of Nile mud. The duty of water is estimated in the roughest way. Rice requires a constant stream and much manure; cotton and sugar are watered every two or three weeks; the first needing a small, but the second a liberal allowance in each watering. The quantity of water said to be employed for such crops from perennial canals in the Delta is uncertain, but appears to supply from 1½ acres to 2½ acres per cubic foot per minute. With beans, lentils, and maize a considerably higher duty is obtained. Under the inundation system the one watering given appears to show a minimum of 6 cubic feet per minute to the acre; but this varies greatly in different districts. Cereals are grown chiefly in Upper Egypt, under the primitive system, being sown in the ground after its inundation, without plowing, and not needing to be irrigated. A considerable area is under pasture, each group of cultivators having its small patch, upon which their sheep, or usually tethered camels, asses, and buffaloes are fed; but much green stuff is cut, always by hand, either for transport to the cities or for feeding cattle. The canals are greatly used for carrying produce to market or to the railway. But even the great advantages they offer for this purpose have been hitherto but imperfectly enjoyed, owing to the numerous illegal obstructions placed upon them, and unjust exactions in the shape of tolls.

The great natural advantages of the country have their compensating disadvantages. The land near the river banks is about 17 feet above its low-water level. The fall is very regular, and is reckoned at 5 inches to the mile along the river, and about the same away from it. This renders the excavation of canals easy, as in our northern plains, but makes continuous cleansing necessary and drainage difficult, and causes loss from soakage along the ditches. In summer the regulators upon them are closed, and they become storages. The Nile water, richly laden with fertilizing materials, deposits it in the channel as well

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as in the fields, sometimes, when they have been dammed to a depth of 8 feet. The dredging of the Ibrahimieh Canal costs over $200,000 a year, and on the other canals it is reckoned to occupy 60,000 men for five months in the year. The annual state outlay upon the canals is $3,000,000, a large portion of which is spent in cleansing them. Mr. L. D'A. Jackson, civil engineer (Hydraulic Works, 1885), calculates that the work required to be done each year by private proprietors and by the state is equivalent to the removal of 500,000,000 cubic feet of silt a distance of 200 feet, and to a height of 40 feet, at an expense of $2,500,000 for the perrennial canals of Lower Egypt alone. In 1884, $290,000, and in 1885, $305,000, was spent in works of protection against the Nile, which is embanked for many miles by dikes of great antiquity. The drainage difficulty is even more serious, and by the neglect of proper provisions for the removal of the surplus waters large tracts of land have been soured or water-logged. The subterranean up-flow has to be provided against as much as floods upon the surface. Indeed, it is water rising through the soil that brings to the surface the salts which do the chief damage. There are very few proper locks or sluices, and constant saturation sometimes causes seed to rot in the soil. Under present control these dangers are being faced; old drainage canals are being straightened and cleared of obstructions; improper levels rectified, and new arterial drains, 20 and 30 miles long, projected. The evil is probably aggravated by extravagance in the use of water. The soil has, in places, those signs which, in America, would be considered distinct evidences of over-watering.

The use of manure has grown, and is growing, since the perennial canals do not carry the sediment which, coming down in the annual inundations, had hitherto acted as a fertilizer. Crops, such as cotton and sugar, have already threatened to seriously impoverish the soil unless systematic fertilization is resorted to. Owing to the common use of cattle-droppings for fuel, it is only pigeon dung that is generally employed, and, of course, in but very limited quantities, though great numbers of them are reared in every homestead for this purpose, and large quantities are brought from Upper Egypt every year. A great deal of fertilizing earth has been obtained from the ruins of ancient villages, once built of unbaked clay, but this requires to be used with care and discrimination on account of its varying elements. It is something, however, to find the value of manure acknowledged by those who use the rich waters of the Nile.

Fearing the failure of the immense masonry barrage which crosses both branches of the Nile a short distance below Cairo at the head of the Delta, upon which the supply of water to the perennial canals largely depends, the government, in 1885, made an agreement with the Irrigation Society of Behera, by which it undertook to pay $210,000 a year for thirty years for a supply up to a certain level, with a maximum of about 156,250 cubic feet per minute at Low Nile, lifted by two powerful sets of steam pumps into the Western Canal or Rayah Behera. The weir has since been rendered secure, but the agreement indicates the value of water and the difficulty of obtaining it, even in parts of Egypt. Owing to the defective alignment of some of the silting up of other canals, the task of raising the water a second time from the channels to the fields has been cast upon a large, if not the largest, body of the cultivators. In 1864, according to Figari Bey, the number of sâkiyehs, or wooden water-wheels, used in Central and Lower Egypt was about 50,000, turned by 200,000 oxen, and managed by 100,000 persons, who watered 4,500,000 acres. The water-wheels are of several varieties,

costing, on the average with the well, $150 each, that most in use sufficing for 5 acres, or 10 acres if worked day and night, and employing three bullocks and two men on each shift. In the estimate of Figari Bey some steam pumps were probably overlooked, for, twenty years later, there were 2,000 of these at work in Lower Egypt, with coal ranging from $10 to $20 per ton. It can now be bought in Alexandria for $5 per ton. The cost of steam pumping is about $1.50, but the price at which it can be hired varies from $2 up to $5 per acre. If paid in kind, the charge is one-fifth of a cotton, and one-quarter of a rice crop, as the latter requires more water. A 10-horse power engine gives an ample supply for 100 acres during the season. There are also "shadoofs" (Egyptian water-lifters, or swing buckets) innumerable in constant employ, which require six men to keep watered 1 acre of cotton or sugar-cane, or 2 of barley.

Over 1,000,000 acres of the irrigated land belongs to the State, the Fellâhin upon them being its tenants, with a life interest and a title to their improvements; half as much is included in great estates, while the balance is in the hands of small proprietors. Omdehs, or notables, and sheiks, who control the village communes, often own estates of 1,000 or even 2,000 acres, but the holdings of the great majority of their constituents, who are working proprietors, are very small. The Crown tenants, of course, pay rent, but all pay a "land tax" of from $1 to $8 per acre, which might be more properly named a water rent, as no tax is levied if no water is given. It is clear that, if in addition to the taxes there is the cost of pumping and four months' labor taken by the *corvée*, the produce must be great to yield any profit to the cultivator. The cost of the crop, including taxes and pumping, averages $25 per acre. The value of land averages $60 per acre in Upper Egypt, and from $100 to $125 in Lower Egypt, but it not infrequently reaches $100 in the one and $300 to $350 in the other. Its variation may be judged from the fact that rents run from 50 cents to $50 per acre. Labor, of course, is plentiful and cheap—wages averaging from ten to fourteen cents per day—but on the other hand the agricultural implements employed are of the most primitive character; the plow used is made on the same model as is delineated upon monuments thousands of years old, and the Nile mud, though freely and easily worked after the subsidence of the water, requires constant attention throughout the year.

The principal products are cotton, wheat, barley, beans, maize, sugar-cane, rice, and clover. In the Delta, those grown in summer are cotton, rice, sugar-cane, melons, cucumbers and clover. During the floods the maize, cotton, rice, and sugar-cane are cultivated. The winter crops are wheat, beans, barley, and clover. The common rotation is a first year of cotton and clover, a second year of maize, wheat, and clover, and a third year of maize, beans, and clover. Cotton is too exhausting to the soil to be grown every year. It could be grown every second year if the water supply were larger, but the present practice is to grow it every third year only, or, what is the same thing, not more than one third of a farm is put under this crop in each year. It is by far the most profitable product in Egypt, an acre being worth from $75 to $125, as against $35 for rice, $25 for wheat, and $20 per acre for fodder, beans, maize, or lentils. In Upper Egypt, wheat, flax, and beans are chiefly sown, while by the use of sâkiyehs and shadoofs, millet, cucumbers, and melons are grown in summer. The food of the country, which is grown by irrigation, of course does not appear in this return. Some fruit is grown, a great deal of forage, and a great variety of vegetables.

Trees are comparatively rare in the Delta; but larger estates are sometimes planted with figs, mulberries, acacias, and sycamores, while the growth of other varieties, notably of the weeping willow, myrtle, elm, and cypress, are now being encouraged. Numbers of date palms are grown upon its borders. Large estates are reckoned to return a profit to their landlords, taking one year with another, of $25 per acre; those of moderate size, also with hired labor, $22.50 per acre, while the fellâhin, in their own plots and with their own family labor, gain as much as $32.50 per acre, irrigation here, as in France and Spain, favoring the small proprietors. The immense Khedivial plantations farmed by the State with most expensive machinery gave a profit of only $6.25 per acre. Since they have been let to private proprietors they have returned a rent of $7.50 per acre.

It should be noted that under despotic government and with the state undertaking the chief irrigation works the local communes are intrusted with the retailing of water. Where the state has attempted to irrigate on public estates it has only achieved a miserable failure. Beyond this the lessons of Egyptian experience, though somewhat vague in detail, point clearly enough to the importance of the questions of silt, drainage, and fertilization, as presenting the most important of the difficulties to be surmounted.

A French estimate of the total population in 1800 was 2,000,000; it is now nearly 7,000,000. The country, however, practically depends for its resources upon the fellâhin, who are less than a third of this number. Upon them and their labors rest the whole superstructure of Egyptian society. The population of 5,000,000, and a national debt of $515,000,000—all are supported by the fruits of irrigation and the industry of 2,000,000 irrigators.

The total area of Egypt (land and water) is about 8,000,000 feddans, or 8,240,000 acres (1 feddan = 1.03 acres). Of this, 4,963,460 feddans, or 5,112,364 acres. Agricultural population forms 61 per cent. of the total. Total population, 6,817,265. There is an annual increase of population of 1.25 per cent.

	Population.	No. of villages.	No. of farm animals for every 103 acres.
Lower Egypt	3,965,664	2,359	17
Upper Egypt	2,776,982	1,420	13

The crops of Egypt, wholly the result of irrigation in 1888, were:

	Acres.
Wheat	1,237,260
Maize and durrah	709,180
Clover	1,236,515
Cotton	994,743
Beans	1,051,875
Barley	601,784
Lentils	113,489
Rice	166,822
All other crops	294,612
Total	6,386,300

In Lower Egypt the soil yields four crops in three years; in Upper Egypt, seven crops in eight years.

In 1888 the "double cultivation" was 1,503,057 acres. In 1888 the exports amounted to £10,418,212, or $52,091,065. In 1800, the popula-

tion was 2,000,000; by the census of 1882 it was nearly 7,000,000. It is now fully that number.

BRITISH INDIA.

Irrigation in British India sustains the largest population, and is the most costly and extensive in the world. It has been practiced on the Indian peninsula from time immemorial. During the past third of a century, owing to the failure of the ancient works and the consequent destruction of crops with accompanying famine, the British rulers have been compelled to assume large risks and make great outlays. It is estimated that about $120,000,000 have been expended under government direction for irrigation work alone. As much more has also been used in the construction of canals for navigation, highways, and country roads as well as railroads, for the purpose of making markets for the crops raised under the new system.

The total population was estimated in 1888 at 269,477,728. The total area in square miles is 1,378,044. The average density per square mile of population is 184.3. Over two-sevenths of the entire population are connected with agriculture. Total area cultivated is given for 1888 at 144,006,000 acres. Of this area 24,836,000 acres are under irrigation.

The area most highly irrigated is the territorial divisions known as the northwest provinces and Oudh. It includes the great canal system of the Upper and Lower Ganges; other works of the largest magnitude are found therein. There are 68,000,000 acres cultivated, of which only 5,000,000 are under ditch. Wells are used largely in these provinces; they number several thousand and serve about 2,000,000 acres of land. No statistics of well irrigation are kept. The Punjab includes an area somewhat larger. The total irrigated by canal is now about 2,000,000 acres. About 1,500,000 acres cover, it is estimated, the area irrigated by wells. In the Presidency of Bombay, with a total area of nearly 79,500,000 acres, the area irrigated from all sources does not exceed 1,600,000 acres; the area irrigated from public works being less than 750,000 acres.

In the Madras Presidency, out of an area of 89,500,000 acres not more than 3 per cent. is irrigated from public works. The total area under irrigation will not exceed 5,500,000 acres. Of the population of British India and its native dependencies it is estimated that at least 20,000,000 persons are supported from land irrigated by village and neighborhood wells. The storage reservoir system is of enormous extent and great importance. In the island of Ceylon alone over 5,000 irrigation tanks and reservoirs are reported. In the province of Mysore, India, 20,000 such tanks are reported. The number, large and small, will run into the hundreds of thousands. The average duty of water will range from 200 to 400 acres, according to locality. The snows from the Himalyan ranges afford a vast reserve against the enormous evaporation, which is a consequence of the equatorial position of British India. The great extent of the country and the differences in physical configuration and climate produce considerable variety in rain-fall and seasons.

Near the mountains irrigation is almost unnecessary, but the decrease in quantity is extremely rapid. North of the Punjab, near the foothills, the mean annual fall is 115 inches; 30 miles distant it is but 31 inches, descending to 20 inches at 70 miles, 15 at 100 miles, and 6 inches at 350 miles from the mountains. In the Sind the average rain-fall will be less than 7 inches, while in the southern portions of the peninsula it will range from 80 to 100 inches.

The following table, though not of as recent date as desirable, will give a clear view of the British Indian irrigation system:

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Statistics of Indian canals, collected from Jackson's and other engineers' works.

Name of canal.	Source of supply.	Length, including branches, etc.	Width.	Depth.	Fall per mile.	Discharge per second.	Area irrigated.	Outlay, 1877–'78.	Revenue, 1877–'78.	Interest.	Working expenses.	Profit and loss.
			Feet.	*Feet.*	*Feet.*	*Cu. feet.*	*Acres.*					*Per cent.*
Ganges	Ganges	4,010	140–110	10 – 8	1.5	6,750	1,045,013	3,055,015	275,462	127,192	105,462	1.51
Western Jumna	Jumna	415	360–120	4½– 2½	.....	.....	507,974	575,921	141,000	19,474	37,516	19.42
Eastern Jumna	....do	748	.....	.....	.....	.....	206,732	261,235	81,401	10,428	23,027	20.68
Boree Doab	Ravi	1,185	120–112	4½– 2½	.....	3,000	266,995	1,537,990	93,876	67,955	50,240	– 1.62
Agra	Jumna	453	140– 70	10 – 7	.....	2,000	163,634	804,479	3,709	32,215	8,819	– 5.14
Dun	Small streams	66	.....	.....	.....	.....	13,202	62,452	5,196	2,727	2,539	– .12
Sirhind	Sutlej	530	200 *b.*	28 –10	.....	4,500	788,000	1,537,990	.....	53,077	.....	– 4.5
Upper Sutlej and Chenab	....do	223	60– 20	6 – 3	.....	.....	94,621	56,812	8,362	2,322	11,307	–10.19
Lower Sutlej	....do	690	.....	.....	.....	.....	284,680	10,808	21,883	486	16,370	46.59
Orissa*	Mahanaddi	228	160	7	.....	.....	183,000	1,778,090	4,549	74,591	20,762	– 5.48
Sone	Sone	331	180 *b.*	9	.....	.....	241,990	1,908,504	5,090	68,461	11,543	– 4.92
Shahpur and Shahiwal	Jhelum	36	18– 10	6 – 4½	.....	.....	4,445	3,757	625	95	522	.35
Tambaddra†	Tambaddra	195	†106– 90*b*	9 – 8	.3–.5	3,000	183,300	1,708,211	.....	.....	.....	.....
Punjab	Indus	618	.....	6 – 3	.....	.....	180,137	57,547	22,140	2,589	19,001	.95
Sind, Shahadadpur, Sukkur	....do	428	.....	.....	.....	.....	171,465	126,081	20,722	5,265	.....	4.59
Eastern Nara	....do	214	206– 20	16 – 4	.....	.....	194,803	323,881	17,961	12,610	.....	1.91
Mutha	Mutha	140	.....	.....	.....	450	5,361	584,956	2,514	17,097	.....	– 3.5
Krishna	Krishna	45	.....	.....	.....	382	2,934	89,016	1,198	5,189	.....	– 3.4
Godavari	Godavari	882	225–114	8 –21	.....	.....	1,000,000	787,778	163,328	33,140	35,837	12.94
Kistna	Kistna	611	230–200	8	.....	.....	470,000	484,590	91,094	20,861	24,603	9.8
Pennair	Pennair	200	.....	.....	.....	.....	70,000	134,020	.....	6,031	.....	– 4.5
Vellore	Vellar	.....	.....	.....	.....	.....	224,219	25,300	.....	1,139	.....	– 4.5
Palar	Palar	.....	.....	.....	.....	.....	37,672	108,371	2,102	4,877	1,012	– 3.5
Cauvery	Cauvery	646	.....	.....	1.5	1,637	796,968	133,964	116,071	6,028	1,120	81.30

*Protects from inundation 249,000 acres.

† Seventeen locks for 868 feet fall.

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The legal regulations in British India rest largely upon the canal act of 1873, framed upon the reports made to the Imperial Government by two prominent engineers who visited Egypt and southern Europe for the purposes of investigation. This act relates to northern India only. Madras and Bombay have their own government, organizing such work under "Orders in Council," and they do it very badly.

The northern India canal and drainage act asserts the right of the State "to use and control for public purposes the water of all rivers and streams flowing in natural channels, and of all lakes and natural collections of still water." The act is of an elaborate character, organizing a great staff of canal officers, giving power to enter private lands, defining compensation, procedure for granting water supplies, levying rates, constructing works, and granting all the powers necessary to carry on such vast stations. The Imperial administration has been a success. All attempts to engraft local self-government are a conceded failure. The general verdict unites favorably on the proposition that the Government investment has paid in actual dividends as well as in good order and prosperity to the people.

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A BRIEF MEMORANDUM

OF THE

DECISIONS

OF THE

FEDERAL, STATE, AND TERRITORIAL COURTS

UPON

QUESTIONS RELATIVE TO THE USE AND CONTROL OF THE WATER IN THE ARID REGION OF THE UNITED STATES.

PART VII.

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BRIEF OF DECISIONS*.

Abandonment.

When the water of a stream leaves the possession of a party, all his right to and interest in it is gone.
Eddy *v.* Simpson, 3 Cal., 249.

If an appropriator of water, after using the same, allows it to return to the stream without intention of using it again, that water becomes a part of the stream, and is subject to appropriation by another.
Eddy *v.* Simpson, 3 Cal., 249; Schulz *v.* Sweeny, 19 Nev., 359; Woolman *v.* Garringer, 1 Mont., 535.

The prior appropriator can not claim water after it has been abandoned by him and appropriated by another.
Eddy *v.* Simpson, 3 Cal., 249; Barkley *v.* Tieleke, 2 Mont., 59.

Rights of a prior appropriator of water may be lost by his acquiescence in an adverse use thereof by another during the period limited by the statute of limitations. This would not apply to any portion of said water of which the prior appropriator did within said period resume, and afterwards, retain possession.
Union Water Company *v.* Crary, 25 Cal., 504; Davis *v.* Gale, 32 Cal., 26; Smith *v.* Logan, 18 Nev., 149; Woolman *v.* Garringer, 1 Mont., 535.

The attempt to convey a water right by an imperfect conveyance, while it may not operate as an absolute transfer, clearly operates as an abandonment by the grantor of his right acquired by appropriation, and the right of the buyer relates to the date of his taking possession as an original appropriation by him.
Barkley *v.* Tieleke, 2 Mont., 59.

One who has abandoned his prior right to the use of water can not by afterwards making a sale of the same revive his prior right in favor of his grantees, even if the same is made in good faith.
Davis *v.* Gale, 32 Cal., 26.

Abandonment, evidence of.

An appropriator of water who for many years makes no use of the water, allows his ditch to become obliterated, and interposes no objection to the diversion of the water by a subsequent appropriator, will be presumed to have abandoned his right of priority.
Dorr *v.* Hammond, 7 Colo., 79.

The facts that water was appropriated for a particular purpose, and that the purpose has been fully accomplished, and that when accomplished the appropriators dispersed, and allowed a long time to elapse without using the ditch, and then sold it for a nominal sum, may be received in evidence as tending to show abandonment.
Davis *v.* Gale, 32 Cal., 26.

A failure to use for a time is competent evidence on the question of abandonment; and if such non-use be continued for an unreasonable period, it may fairly create a presumption of intention to abandon, but this presumption is not conclusive, and may be overcome by other satisfactory proofs.
Davis *v.* Gale, 32 Cal., 26; Sieber *v.* Frink, 7 Colo., 148.

Abatement of nuisance.

See Actions for diversion of water, Nuisance.

Acquiescence.

See Abandonment, Estoppel, Prescription.

* This brief of decision is enlarged from one made for the United States Irrigation Survey and published by the Interior Department (1890). The table of cases and the digest of decisions down to April, 1890, have been prepared under the direction of the editor.

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Act of Congress.

See Statutes.

Action against trespassers, who may maintain.

A party who is in possession of a ditch and the water incident thereto has an equitable interest therein, and can maintain an action against trespassers.
Barkley *v.* Tieleke, 2 Mont., 59.

Action for diversion of water, tenants in common.

Actions for diversion of the waters of ditches are in the nature of actions for the abatement of nuisances, and may be maintained by tenants in common in a joint action.
Parke *v.* Kilham, 8 Cal., 77.

In an action for the diversion of water from a ditch and land owned by the plaintiff and others, his co-owners are not necessary parties.
Himes *v.* Johnson, 61 Cal., 259.

Action for injury to water rights, who may maintain.

One to whom lands have been conveyed acquires thereby the legal title to such lands, even though there may be an oral agreement to reconvey, and may maintain an action to establish water rights connected with said land.
Smith *v.* Logan, 18 Nev., 149.

Action for invasion of water right, who may maintain.

Until a claimant is himself in a position to use water, the right to the water does not exist in such a sense that the mere diversion and use of the water by another is a ground of action either to recover the water or damages for the diversion.
N. C. & S. Canal Co. *v.* Kidd, 37 Cal., 282.

Adverse use.

See Prescription.

Agriculturists and miners.

See Miners and Agriculturists, relative rights of, Miners' rights not superior to others.

Application to beneficial use.

See Appropriation.

Appropriation.

The first appropriator of water from a natural stream upon the public lands for a beneficial purpose has a prior right thereto to the extent of such appropriation.
Atchison *v.* Peterson, 20 Wall., 507; Basey *v.* Gallagher, 20 Wall., 670; Irwin *v.* Phillips, 5 Cal., 140; Tartar *v.* Spring Creek M. & Mg. Co., 5 Cal., 395; Hill *v.* Newman, 5 Cal., 445; Conger *v.* Weaver, 6 Cal., 548; Hoffman *v.* Stone, 7 Cal., 47; B. R. and A. W. and M. Co. *v.* N. Y. Mg. Co., 8 Cal., 327: Hill *v.* King, 8 Cal., 336; Butte Canal and Ditch Co. *v.* Vaughn, 11 Cal., 143; Ortman *v.* Dixon, 13 Cal., 33; McKinney *v.* Smith, 21 Cal., 374; Union Water Co. *v.* Crary, 25 Cal., 504; Davis *v.* Gale, 32 Cal., 26; Osgood *v.* El Dorado W. and M. Co., 56 Cal., 571; Himes *v.* Johnson, 61 Cal., 259; Brown *v.* Mullin, 65 Cal., 89; Junkans *v.* Bergin, 67 Cal., 267; Ware *v.* Walker, 70 Cal., 591; Schilling *v.* Rominger, 4 Colo., 100; Coffin *v.* Left-Hand Ditch Co., 6 Colo., 443; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582; Golden Canal Co. *v.* Bright, 8 Colo., 144; Hammond *v.* Rose, 11 Colo., 524; Lobdell *v.* Simpson, 2 Nev., 274; Ophir Silver Mg. Co. *v.* Carpenter, 4 Nev., 534; Dalton *v.* Bowker, 8 Nev., 190; Barnes *v.* Sabron, 10 Nev., 217; Strait *v.* Brown, 16 Nev., 317; Jones *v.* Adams, 19 Nev., 78; Atchison *v.* Peterson, 1 Mont., 561; Barkley *v.* Tieleke, 2 Mont., 59; Keeney *v.* Carillo, 2 N. M., 480; Farmers' High Line Canal *v.* Southworth (Colo.), Lawyer's Rep. (1889) IV, 767; Crane *v.* Winsor, 2 Utah, 248; Monroe *v.* Ivie, 2 Utah, 535; Kaler *v.* Campbell, 13 Ore., 596.

The diversion of the waters of a stream with the object of drainage simply, or without the intention of applying them to some useful purpose, does not constitute an appropriation.
Maeris *v.* Bicknell, 7 Cal., 261; McKinney *v.* Smith, 21 Cal., 374; Thomas *v.* Guiraud, 6 Colo., 530,

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Appropriation—Continued.

One who uses the waste water from the mining operations of another acquires by such use no right, unless that water had been turned back into the original channel without any intention of recapture, and thus became *publici juris*.

Woolman *v.* Garringer, 1 Mont., 535.

To constitute a legal appropriation, the water claimed must be applied to some beneficial use or purpose.

Maeris *v.* Bicknell, 7 Cal., 261; Weaver *v.* Eureka Lake Co., 15 Cal., 271; Davis *v.* Gale, 32 Cal., 26; Sieber *v.* Frink, 7 Colo., 148; Larimer R. Co. *v.* People, *ex rel.* Luthe, 8 Colo., 614; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582; Dick *v.* Caldwell, 14 Nev., 167; Farmers' High Line Canal *v.* Southworth (Colo.), Lawyers' Rep. (1889), IV, 767.

The true test of appropriation of water is the successful application thereof to the beneficial use designed, and the method of diverting or carrying the same, or making such application, is immaterial.

Thomas *v.* Guiraud, 6 Colo., 530.

If land be rendered productive by the natural overflow of water thereon without the aid of any appliances whatever, the cultivation of such land by means of the water so naturally moistening the same is a sufficient appropriation of such water to the amount necessary for such use.

Thomas *v.* Guiraud, 6 Colo., 530.

Appropriation completed, relates back:

Although the appropriation is not deemed complete until the actual diversion or use of the water, still if such work be prosecuted with reasonable diligence, the right relates to the time when the first step was taken to secure it.

Kelley *v.* Natoma Water Co., 6 Cal., 105; Maeris *v.* Bicknell, 7 Cal., 261; Kimball *v.* Gearhart, 12 Cal., 27; N. C. & S. C. Co. *v.* Kidd, 37 Cal., 282; Osgood *v.* Water and Mining Co., 56 Cal., 571; Ophir Mining Co. *v.* Carpenter, 4 Nev., 534; Irwin *v.* Strait, 18 Nev., 436; Sieber *v.* Frink, 7 Colo., 148; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582; Columbia Mg. Co. *v.* Holter, 1 Mont., 296.

Appropriation, diligence:

To acquire a right to water from the date of the diversion thereof, one must, within a reasonable time, employ the same in the business for which the appropriation is made. What shall constitute such reasonable time is a question of fact, depending upon the circumstances connected with each particular case.

Conger *v.* Weaver, 6 Cal., 543; Maeris *v.* Bicknell, 7 Cal., 261; Parke *v.* Kilham, 8 Cal., 77; Kimball *v.* Gearhart, 12 Cal., 27; Weaver *v.* Eureka Lake Co., 15 Cal., 271; Sieber *v.* Frink, 7 Colo., 148; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582; Atchison *v.* Peterson, 1 Mont., 561; Keeney *v.* Carillo, 2 N. M., 480; Ophir S. M. Co. *v.* Carpenter, 4 Nev., 534.

Diligence in the prosecution of work such as the appropriation of water by constructing a ditch for its use does not require unusual or extraordinary efforts, but only such constancy or steadiness of purpose or labor as is usual with men engaged in like enterprises, who desire a speedy accomplishment of their designs; such assiduity in its prosecution as will manifest a bona fide intention to complete it within a reasonable time.

Kimball *v.* Gearhart, 12 Cal., 27; Ophir S. Mg. Co. *v.* Carpenter, 4 Nev., 534.

Appropriation, extent of.

The appropriation of the water of a stream for a particular purpose is an appropriation of only so much of the water as is necessary for that purpose, and the surplus, if any, may be taken by others.

Ortman *v.* Dixon, 13 Cal., 33; McKinney *v.* Smith, 21 Cal., 374; Davis *v.* Gale, 32 Cal., 26; Nevada Water Co. *v.* Powell, 34 Cal., 109; N. C. & S. C. Co. *v.* Kidd, 37 Cal., 282; Edgar *v.* Stevenson, 70 Cal., 286; Butte Canal & Ditch Co. *v.* Vaughn, 11 Cal., 143; Barnes *v.* Sabron, 10 Nev., 217; Simpson *v.* Williams, 18 Nev., 432; Lobdell *v.* Simpson, 2 Nev., 274; Sieber *v.* Frink, 7 Colo., 148.

The quantity of water appropriated in any given case is to be measured by the capacity of the ditch or flume at its smallest voint; that is, at the point where the least water can be carried through it.

Higgins *v.* Barker, 42 Cal., 233; Atchison *v.* Peterson, 20 Wall., 507; Ophir Mining Co. *v.* Carpenter, 6 Nev., 393; Caruthers *v.* Pemberton, 1 Mont., 111.

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Appropriation, extent of—Continued.

Appropriation of all water in a stream means as it ordinarily flows, and another may take the surplus in times of extraordinary high water or freshets.
Edgar *v.* Stevenson, 70 Cal., 286.

In determining the quantity of water appropriated it is proper to consider the acts of the appropriator, the manner in which the ditch was constructed, the general size, etc. The appropriator would not be limited to the quantity turned into his ditch in the first place, unless by the general plan, size, and grade of the ditch it was not capable of carrying more than was first diverted. If by reason of obstructions or irregularity in the grade of the ditch it was not capable of diverting as much water as its general size would indicate, the appropriator would be allowed a reasonable time to remove such obstructions or adjust the grade, and then fill the ditch to its capacity.
White *v.* Todd's Valley Water Co., 8 Cal., 443.

The erection of a dam across a natural water-course is an actual appropriation of the waters of the stream to that point, but no farther. Any one may appropriate the water found below the dam.
Kelly *v* Natoma Water Co., 6 Cal., 105.

If one appropriates a part of the waters of a stream for a certain period of time, any other person may not only appropriate the residue and acquire a right thereto as perfect as the first appropriator, but may also acquire a right to the quantity of water used by the first appropriator at such times as it is not needed or used by him.
Smith *v.* O'Hara, 43 Cal., 371; Barnes *v.* Sabron, 10 Nev., 217.

The right to acquire, by the prior appropriator is limited to the amount of water appropriated. In subordination to his right thus limited others may appropriate the remainder of the water running in the stream.
Butte Canal & Ditch Co. *v.* Vaughn, 11 Cal., 143; Ortman *v.* Dixon, 13 Cal., 33; McKinney *v.* Smith, 21 Cal., 374; Nevada Water Co. *v.* Powell, 34 Cal., 109; Higgins *v.* Barker, 42 Cal., 233; Brown *v.* Mullin, 65 Cal., 89; Junkans *v.* Bergin, 67 Cal., 267; Lobdell *v.* Simpson, 2 Nev., 274; Proctor *v.* Jennings, 6 Nev., 83; Barnes *v.* Sabron, 10 Nev., 217; Strait *v.* Brown, 16 Nev., 317; Chiatovich *v.* Davis, 17 Nev., 133; Thomas *v.* Guiraud, 6 Colo., 530.

The prior appropriator has a right to have the water so appropriated flow down to the point of his appropriation undiminished in quantity and quality. A subsequent appropriator would have the right to use water from said stream in such a manner as not to cause any positive or sensible injury to the former appropriator.
Bear River & Auburn W. & M. Co. *v.* N. Y. Mg. Co., 8 Cal., 327; Hill *v.* King, 8 Cal., 336; Butte Canal and Ditch Co. *v.* Vaughn, 11 Cal., 143; Phœnix Water Co. *v.* Fletcher, 23 Cal., 482; Natoma W. & M. Co. *v.* McCoy, 23 Cal., 491; Nevada Water Co. *v.* Powell, 34 Cal., 109; Stein Canal Co. *v.* Kern Island Irr. C. Co., 53 Cal., 563; Lobdell *v.* Simpson, 2 Nev., 274; Crane *v.* Winsor, 2 Utah, 248.

The right of a riparian proprietor to the waters of a river should be determined by the application of the principles of prior appropriation.
Reno Smelting M. & R. Works *v.* Stevenson (Nev.) Lawyers' Rep., 1889, IV, 60.

A subsequent appropriator from a natural stream has no right to destroy the ditch of a prior appropriator, or to materially diminish the quantity or deteriorate the quality of the water to which the latter is entitled; nor has the prior appropriator a right to extend his use of water to the prejudice of the subsequent appropriator.
McKinney *v.* Smith, 21 Cal., 374; Nevada Water Co. *v.* Powell, 34 Cal., 109; Higgins *v.* Barker, 42 Cal., 233; Stein Canal Co. *v.* Kern Island Irr. Co., 53 Cal., 563; Brown *v.* Mullin, 65 Cal., 89; Junkans *v.* Bergin, 67 Cal., 267; Lobdell *v.* Simpson, 2 Nev., 274; Proctor *v.* Jennings, 6 Nev., 83; Sieber *v.* Frink, 7 Colo., 148; Larimer County R. Co. *v.* People, *ex rel.*, 8 Colo., 614.

The right to use water for purposes of irrigation, when its use is not indispensable, but for the purpose of increasing the products of the soil, must be subordinate to the right of a co-proprietor to supply his family, tenants, etc., their natural wants for necessary and domestic purposes.
Baker *v.* Brown, 55 Tex., 377.

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Appropriation, extent of, character of use considered in determining.

A beneficial use, without regard to the nature thereof, will sustain the right by appropriation; but the nature of the use may be important as denoting the extent of the water appropriated. Water taken for a mill is not taken as an article of merchandise, to be sold in the market; it is merely taken for use as a motive power, and, having subserved this purpose, may be taken by others.

McDonald *v.* Bear River & Auburn W. & M. Co., 13 Cal., 220.

The appropriation of water to a beneficial use by consumers receiving it through a ditch belonging to a public carrier of water is accomplished at the time the water is actually used beneficially by the consumer, and consumers thereof are not necessarily upon an equality, but may have different priorities of right.

Farmers' High Line Canal *v.* Southworth (Colo.), Lawyers' Rep. (1889), IV, 767.

Appropriation, Indian may acquire right by.

An Indian may acquire a right to the use of water on the public lands by appropriation, and may maintain an action for diversion of such water. This right would carry with it the right to repair a temporary damage to his ditch or dam, and those who might obtain possession under him would have the same right.

Lobdell *v.* Hall, 3 Nev., 507.

Appropriation, manner of making, may be regulated by the legislature.

The legislature can not prohibit the appropriation or diversion of unappropriated water for useful purposes from natural streams upon the public domain, but it may regulate the manner of effecting such appropriation or diversion, and may designate how the water shall be turned from the stream or how it shall be stored and preserved.

Larimer County R. Co. *v.* The People, 8 Colo., 614.

Appropriation, notice, effect of.

A notice of intention to appropriate is evidence of possession, but of itself alone is not sufficient. Taken with other acts it amounts to sufficient evidence. It forms one of a series of acts which, taken together, make the right perfect.

Conger *v.* Weaver, 6 Cal., 548; Thompson *v.* Lee, 8 Cal., 275; Columbia Mining Co. *v.* Holter, 1 Mont., 296.

Appropriation of land and water requires different character of acts.

Public land is appropriated by one character of act, water by another. The digging of a ditch on public land is not an appropriation of land for a mill-site, nor is the mere appropriation of a mill-site an appropriation of water for milling purposes.

Robinson *v.* Imperial Silver Mg. Co., 5 Nev., 44.

Appropriation, right attaches when.

Although one may not have completed his work for diverting or using water, and therefore has not completed his appropriation, yet he has a right to the use of so much of the waters of the stream as may be necessary to prevent his works from injury while in the process of construction.

Weaver *v.* Conger, 10 Cal., 233.

Appropriation, rights acquired by.

An appropriation of water at a given point carries with it an implied authority to do all that shall become necessary to secure the benefit of such appropriation. To this extent the appropriator acquires an easement in the adjoining lands. This right is, however, restricted to the narrowest limits, and it must be exercised in such manner as to occasion as little damage as possible to the owner of the adjoining premises.

Crisman *v.* Heiderer, 5 Colo., 589.

The appropriation of water flowing through the public lands confers no right on the appropriator, either against the Government or its grantees, in the absence of Congressional legislation qualifying the effect of the Government patent. And this is so, although the customs, laws, and decisions of the courts of the States wherein the land lies recognize and enforce rights acquired by prior appropriation in controversies between occupants of public lands without title from the Government.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

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Appropriation, rights acquired by—Continued.

By appropriation one acquires only the right of possession and use of water, qualified by the right of others to its use, in such manner as shall not materially diminish or deteriorate it, at the place of his appropriation, in quantity or quality.

Columbia Mining Co. *v.* Holter, 1 Mont., 296; Alder Gulch Con. Mg. Co. *v.* Hayes, 6 Mont., 31.

Appropriators, prior and subsequent.

If two parties have acquired rights to the use of the water in a stream and the volume of that water is increased by others turning into said stream the water from their ditch without intention of retaking it, said increase, becoming *publici juris*, does not affect the relative rights of the appropriators. Those rights remain the same as they would if the increase had been due to a natural cause.

Davis *v.* Gale, 32 Cal., 26.

Priority of appropriation shall determine the right to water of a natural stream; the water is not "appropriated" until it is applied to some beneficial use.

Farmers' High Line Canal *v.* Southworth (Colo.), Lawyer's Rep., Ann. 1889, iv., 767.

Appropriators, relative rights.

The question in controversies between two appropriators where the prior appropriator asks damages from the subsequent appropriator, or seeks to restrain him from using the water is, has the prior appropriator's use and enjoyment of the water for the purposes for which he claims its use been impaired by the acts of the subsequent appropriator?

Atchison *v.* Peterson, 20 Wall., 507; Union Water Co. *v.* Crary, 25 Cal., 504; Hill *v.* Smith, 27 Cal., 476.

Different users of water, obtaining their supply through the same ditch, may, under some circumstances, have different priorities of right to the water.

Farmers' High Line Canal *v.* Southworth (Colo.), Lawyer's Report, Ann. 1889, iv, 767.

The appropriation of mining water is open to all persons, and the legislature has no power to enact laws that will permit an irrigating company to control or manage the water of any part of the Territory in disregard of the rights of individual claimants.

Monroe *v.* Ivie, 2 Utah, 535.

Where several parties who had appropriated water from the same stream at different times and in different amounts entered into a contract to construct a new ditch, their several interests in the water to be carried in such ditch must, in the absence of any direct agreement, remain the same as prior to such contract and construction of such ditch, both as to the quantity to which each was entitled and as to the date his rights attached.

Rominger *v.* Squires, 9 Colo., 327.

The use of water for mining purposes is one of the uses recognized and protected by the laws, both of the State and Federal Governments, and while an appropriator of the water of a natural stream is entitled to have such water flow down to him undiminished in quantity, any deterioration in quality occasioned by the use of it above for mining purposes must be an injury without consequent damages.

Bear River W. Co. *v.* New York Mg. Co., 8 Cal., 327.

Appropriator's right co-extensive with his ditch.

The right to have water flow into a ditch is co-extensive with the ditch itself and when a water-ditch extends into two or more counties an action for damages caused by acts preventing the water from flowing into the ditch, and for an injunction to prevent such acts may be brought in any county into which the ditch extends. Although the act complained of occurred at the head of the ditch, it was injurious to the whole length thereof.

Lower Kings R. D. Co. *v.* Lower Kings R. & F. Co., 60 Cal., 408.

Appropriator's rights in water in a natural stream usufructuary.

An appropriator of water so long as such water continues to flow in its natural course acquires no specific property in the water itself. His rights, like those of a riparian owner, are strictly usufructuary.

Eddy *v.* Simpson, 3 Cal., 249; Kidd *v.* Laird, 15 Cal., 161; McDonald *v.* Askew, 29 Cal., 200; Alder Gulch Con. Mg. Co. *v* Hayes, 6 Mont., 31.

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Appropriator, right to remove obstructions.

An appropriator of the waters of a natural stream flowing through public lands has a right, as against subsequent purchasers from the United States, to go upon the land of such purchaser higher up the stream than the point of diversion and remove obstructions from the bed of the stream, so as to cause its waters to flow in their natural channel to the point of diversion.

Ware *v.* Walker, 70 Cal., 591.

Appropriators tenants in common.

Where different persons separately appropriate the waters of a stream and are severally using the same under certain regulations as to the time and manner of such use they are tenants in common, and each of them may maintain an action to enjoin a tresspasser from diverting any portion of the water thus appropriated.

Lytle Creek Water Co. *v.* Perdew, 65 Cal., 447.

Appurtenance.

See Water-right.

Covenant which runs with land.

A covenant between two adjoining land-owners to appropriate and convey the waters of a stream into a reservoir for their joint use runs with the land, and the successor of one on whose land the reservoir is situated can not, by changing the point of diversion, claim all the water.

Weill *v.* Baldwin, 64 Cal., 476.

Customs, local, must be proved.

See Practice.

Dam, appropriation by means of.

When one appropriates water by means of a dam and ditch sufficient for the purpose in the natural condition of the stream as it then existed, he may not afterwards raise his dam higher to obviate obstructions to its use occasioned by physical changes in the stream, whether natural or artificial, if such action on his part would work an injury to subsequent appropriators who were not responsible for the changes in the stream.

Nevada Water Co. *v.* Powell, 34 Cal., 109.

Dam, duty of owner.

The owner of a dam is bound to see to his property, and to so govern and control it that injury may not result to his neighbors.

Fraler *v.* Sears Union Water Co., 12 Cal., 555.

Dam, harmless when erected, may not be abated.

A dam erected on a stream in a manner nowise injurious or prejudicial at the time of its erection to rights of others on the same stream, but which, by reason of circumstances that could not have been anticipated, happening subsequently and operating in connection with it, does cause injury to others, is not such an obstruction as to authorize its abatement or justify a recovery of damages against the person so building the dam for injury thus occasioned.

Proctor *v.* Jennings, 6 Nev., 83.

Damages, actual, not necessary to an equitable relief against wrongful diversion of water.

Equitable relief will be granted for a wrongful diversion of water, even though no actual damage is shown. Every violation of a right imports damage, and this principle is applied whenever the act done is of such a nature as that by its repetition or continuance it may become the foundation of an adverse right.

Barnes *v.* Sabron, 10 Nev., 217.

Damages, when actual, necessary to justify an action.

See Injury; not always necessary to justify an action.

Damage by breaking of dam or ditch.

See Negligence.

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Damages from ravine adopted as part of a ditch, who responsible for.

One who adopts a natural water-course as a part of his ditch does so to the extent of the capacity of his ditch, and he is liable for injuries to lands resulting from an overflow of that water-course caused by his failure to have it properly cleared of obstructions or of his turning into it a quantity of water which, added to the natural waters flowing therein, exceeded its carrying capacity.

Richardson *v.* Kier, 34 Cal., 63; Richardson *v.* Kier, 34 Cal., 263.

Damages, liability of corporation to stockholders.

Where several persons owning a ditch and water right form a corporation, the express object of which is to own, keep in repair, and enlarge such ditch, and to control and divide the use of said water for the benefit of the several stockholders in accordance with their interests in the stock of said corporation, that corporation is bound to discharge the duties prescribed in the certificate of incorporation, and for any failure or neglect to discharge these duties it would be liable to any stockholder who is injured thereby to the extent of his damages.

O'Connor *v.* North Truckee Ditch Co., 17 Nev., 245.

Damages, when ditch-owner liable for.

A ditch-owner would be liable for an injury caused wantonly or by gross negligence; but he is not liable for a mere accidental injury, where no negligence is shown, to a miner locating along the line of such ditch subsequently to the construction thereof, neither party claiming ownership of the soil.

Tenney *v.* Miners' Ditch Co., 7 Cal., 335.

Damages, when prior appropriator entitled to recover.

A prior appropriator of water is entitled to recover damages for injuries caused by the acts of subsequent appropriators on the stream above in erecting dams or other obstructions, by which the regularity of the flow of water is so disturbed as to cause actual injury, or in diverting the water to the use of which he is entitled.

Coker *v.* Simpson, 7 Cal., 340; Phœnix Water Co. *v.* Fletcher, 23 Cal., 481; Natoma Water and Mg. Co. *v.* McCoy, 23 Cal., 490.

Deed, construction of.

A deed which conveys a certain tract of land, and also the prior right to the use of a part of the water of a stream flowing through said land, must be construed as conveying a right to water over and above that of a mere riparian owner.

Dalton *v.* Bowker, 8 Nev., 190.

Diligence in perfecting appropriation.

In determining whether the work necessary to the appropriation of water has been prosecuted with diligence, it is proper to take into consideration the circumstances surrounding the parties which would affect any person who might be engaged in the same undertaking, such as the nature and climate of the country, the condition of the weather, and the difficulties of procuring labor and materials.

Kimball *v.* Gearhart, 12 Cal., 27; Ophir S. M. Co. *v.* Carpenter, 4 Nev., 534.

In determining whether diligence has been exercised in prosecuting the work for the appropriation of water, matters incident to the enterprise, and not those incident to the person, such as the illness of the appropriator or his lack of pecuniary means to prosecute the work, are to be considered in excuse for great delay.

Ophir S. M. Co. *v.* Carpenter, 4 Nev., 534; Keeney *v.* Carillo, 2 N. M., 480.

Distribution of water for public use.

See Ditch-owners are public carriers.

Ditch, authority of court of equity over.

If one own a ditch, and right of way for same, a court of equity has no authority by its judgment to allow the ditch to be washed away for mining purposes, even after providing that such portion of the ditch as might be destroyed should be replaced by a metal pipe or flume which would answer all purposes of the ditch. The court should not license a trespass on such property, or compel the owner thereof to exchange the same for other property for the convenience of a private person.

Gregory *v.* Nelson, 41 Cal., 278.

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Ditch capacity, how proved.

The carrying capacity of a ditch is a question of fact, which does not require for its proof unusual scientific attainments or peculiar skill. Men who have acquired a knowledge upon such subjects from experience in mining and in measuring and selling water to miners as non-experts are as competent as experts to testify to the fact.

Frey *v.* Lowden, 70 Cal., 550.

Ditch, conveyance of.

See Right of way, conveyance of, water-right, when an appurtenance.

Ditch, enlargement of.

If one is entitled to all the waters of a stream at the point where his ditch starts out, the capacity of that ditch or its enlargement is of no moment to others having ditches on the stream.

James *v.* Williams, 31 Cal., 211.

Ditch, character of, as an excavation not changed by flumes at different points.

Flumes constructed at different parts of the line of a ditch can not change the general character of the work as an excavation; such flumes are merely connecting links and a part of the ditch. A statute giving a lien for labor bestowed or material furnished upon buildings, wharves, or other superstructures does not include ditches. Equity raises no lien in regard to real estate, except that of a vendor for purchase money.

Ellison *v.* Jackson Water Co., 12 Cal., 542; Horn *v.* Jones, 28 Cal., 194.

Ditches, liability of owner for damages from.

See Negligence.

Ditch-owners and miners, relative rights.

The two rights to work the mines and to divert the water of steams from the natural channels stand upon an equal footing, and when they conflict they must be decided by the fact of priority upon the maxim of equity, *Qui prior est in tempore, potior est in jure.*

Irwin *v.* Phillips, 5 Cal., 140; Wixon *v.* Bear River & Auburn W. & M. Co., 24 Cal., 367; Levaroni *v.* Miller, 34 Cal., 231.

The owner of a mining claim and the owner of a ditch or water-right stand upon the same footing; that is, their respective rights attach from the date of appropriation, the first in time being the first in right; but where both rights can be enjoyed without interference with or material impairment of each other, the enjoyment of both is allowed.

Jennison *v.* Kirk, 98 U. S., 453; Hill *v.* Smith, 27 Cal., 476; Clark *v.* Willett, 35 Cal., 534.

Ditch-owners are public carriers.

Owners of ditches or canals, as such, are carriers and quasi-public servants. They are awarded certain privileges, and are charged with certain duties and subject to reasonable control.

Price *v.* Riverside L. & I. Co., 56 Cal., 431; McCrary *v.* Beaudry, 67 Cal., 120; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582.

Ditch-owners as carriers, duties of.

Ditch-owners, as such, are carriers, and must furnish water at the established rate (the county commissioners being empowered to fix a maximum rate) to the class of persons using it in the manner named in the articles of incorporation.

Golden Canal Co. *v.* Bright, 8 Colo., 144; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582.

Ditch, right of way for.

See Easement, Right of way.

Ditch, water-rights co-extensive with.

See Appropriator's right.

Ditch, repairs of, liability for.

See Estoppel.

Ditch, value of, how proved.

The ordinary way of proving the value of a ditch is by showing its capacity, the value of the water in its vicinity, and the probable duration of the demand.

Clark *v.* Willett, 35 Cal., 534.

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Diversion of water from reservoir will be enjoined, when.

One who constructs on the public lands a reservoir to collect and store, for the purposes of irrigation, the water flowing down a ravine, acquires a vested right of property in the reservoir and water, of which he can not be divested for mining or other private purposes, and a court of equity will enjoin miners from injuring the reservoir or diverting the water therefrom.

Rupley *v.* Welch, 23 Cal., 452.

Diversion of water illegal, may be prevented.

One attempting to illegally divert water belonging to another may be ejected from the possession of ground occupied by him for completing such illegal diversion, and can not complain of the means taken to defeat his object.

Butte Table Mountain Co. *v.* Morgan, 19 Cal., 609.

Diversion of water, liability for.

One who diverts the water of a natural water-course, that was accustomed to flow through the land of another, and that other thereby suffers injury, is liable to damages for the injury thus inflicted.

Ellis *v.* Tone, 58 Cal., 289.

In an action for diversion of water, the defendant is not liable for damages to another appropriator from the same stream resulting from a deficiency of the water supply, unless he was diverting from the stream more water than he was entitled to at the precise time the deficiency complained of existed.

Brown *v.* Smith, 10 Cal., 508.

Diversion of water, pleading in action for.

In an action for diversion of water, the fact that the diversion was accomplished by one means or another is not important enough to require several counts setting forth the different modes of diversion.

Gale *v.* Tuolumne Water Co., 14 Cal., 25.

Diversion, right of.

See Appropriation.

Diversion, right of, as affected by recital in deed.

See Estoppel.

Diversion, riparian owner's right of.

See Riparian rights.

Diversion, sufficient allegation in complaint for.

The allegation, in a complaint for the diversion of water, that the plaintiff was entitled by virtue of prior appropriation to all the water flowing in the stream at the head of his ditch, entitles him to prove a diversion of water from smaller branches of the stream supplying water to that point.

Priest *v.* Union Canal Co., 6 Cal., 170.

Diversion of water, wrongful, may be restrained.

Equity will restrain the continuous wrongful diversion of water at the instance of a prior appropriator thereof, although no actual damages are averred or proved. Equitable relief is granted in such cases to prevent wrongful acts from ripening into a right.

Moore *v.* Clear Lake Water Works, 68 Cal., 146.

Easement for flow of water.

The rule that the owner of a tract of land has an easement in a lower adjacent tract to the extent of burdening it with the water naturally flowing to it from the upper tract applies only to waters naturally so flowing, and the servitude of the lower tract can not be made more burdensome by the acts or industry of man.

Ogburn *v.* Connor, 46 Cal., 346; Boynton *v.* Longley, 19 Nev., 69.

Easement for irrigating purposes.

All lands in this Territory are held in subordination to the dominant right of others who must necessarily pass over them to obtain a supply of water to irrigate their lands. It is not, therefore, necessary that there should be a conveyance in writing to establish an easement for right of way for a ditch.

Yunker *v.* Nichols, 1 Colo., 551.

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Easement, grant of right of way for a ditch.

A grant of the right to all the water in a stream, and of the right to enter on the land of the grantor and construct and maintain all dams, ditches, pipes, or flumes necessary and proper for conveying such water over said land to the place of its use, vests in the grantee the right to convey said water at different times and places, or to change or enlarge his ditch, and to use it in any manner he pleases, if the grantor is not injured by such use.

Spear *v.* Cook, 8 Ore., 380.

Easement on public lands.

See Statutes, act of July 26, 1866, Appropriator, right to remove obstructions.

Easement, right of way for ditch.

A grant of the right of way for a ditch over a tract of land is an easement only, and is not a grant of the land or water flowing over it. When an easement is granted, nothing passes as an incident to such grant but what is necessary for its reasonable and proper enjoyment.

Miller *v.* Vaughn, 8 Ore., 333.

Easement, right of way under act of July 26, 1866.

To one who had, prior to the passage of the act of July 26, 1866, constructed a ditch over public land and had acquired a right to the water carried therein, recognized by the local customs, laws, and decisions of the courts, that act operated as a grant of the right of way, and of the ditch through which the water was running at the date thereof.

Broder *v.* Natoma Water Co., 101 U. S., 274; Broder *v.* Natoma Water Co., 50 Cal., 621.

Eminent domain.

Statutes conferring the power to condemn private property to the use of another without the consent of the owner are in derogation of the common law and must be strictly construed.

San Francisco and Alameda W. Co. *v.* Alameda W. Co., 36 Cal., 639.

The supplying of the inhabitants of a town with pure, fresh water is a public use, in behalf of which a corporation is authorized to exercise the right of eminent domain. The right of an individual to enjoy the flow of water in its natural channel upon or along his land may, under the laws of this State, be condemned for public use.

Heyneman *v.* Blake, 19 Cal., 579; St. Helena Water Co. *v.* Forbes, 62 Cal., 182; Spring Valley W. Works *v.* San Mateo W. Works, 64 Cal., 123; Lux *v.* Haggin, 69 Cal., 255.

The right of eminent domain is restricted to the taking of private property for public use. It can not be exercised in favor of the owners of mining claims, to enable them to obtain water for their own use in working such claims, though the intention may also be to supply the water to others for mining and irrigating purposes.

Lorenz *v.* Jacob, 63 Cal., 73.

To authorize the condemnation of private property there must be a real necessity; the mere fact that it would be convenient and profitable to the corporation to acquire the property would not justify the exercise of the right of eminent domain.

Spring Valley W. Works *v.* San Mateo W. Works, 54 Cal., 123.

The proprietor of an irrigating ditch has a property ownership both in the ditch and the right of way therefor, which can not be taken or damaged for public use, except upon payment of just compensation.

Tripp *v.* Overocker, 7 Colo., 72.

Estoppel.

One having a right by prior appropriation to the use of the waters of a stream, who stands by and allows another to purchase from a third party wrongfully claiming to have the right to said water, without asserting or making known his claim, is estopped from afterwards asserting that claim.

Fabian *v.* Collins, 3 Mont., 215.

If a prior appropriator of the water of a stream stood by and saw another appropriate the water of that stream at great expense, under the mistaken idea that he was thereby acquiring a prior right thereto, and did not inform him of the mistake, he, the prior appropriator, and his vendors are estopped from afterwards claiming such water.

Parke *v.* Kilham, 8 Cal., 78.

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Estoppel—Continued.

The facts that a ditch was constructed at heavy cost and was maintained and used with the knowledge of the true owners, and without any objection or opposition on their part, are not sufficient to operate an estoppel. There must be some degree of turpitude in the conduct of a party before a court of equity will estop him from the assertion of his title.

Biddle Boggs *v.* Merced Mg. Co., 14 Cal., 279; Anaheim Water Co. *v.* Semi-Tropic Water Co., 64 Cal., 185; Stockman *v.* Riverside L. and I. Co., 64 Cal., 57; Lux *v.* Haggin, 69 Cal., 255.

Estoppel, recital in deed.

A recital in a deed to the effect that the grantee is about to divert the waters of a certain stream (which flowed through the grantor's land), and to appropriate the same, followed by a grant of the right of way to conduct water over the land of the grantor, does not estop said grantor from denying the right of the grantee to divert the waters of said stream.

Zimmler, adm'r, *v.* San Luis Water Co., 57 Cal., 221.

Estoppel, use of water, notice.

One who acquires a right to the use of a part of the water of a ditch, not to exceed a certain definite amount, upon condition of paying his *pro rata* share of the needed repairs, has the option of using whatever amount he may desire within the fixed limit and he will not be held liable beyond the proportion so used; if, however, he gives notice that he will require a certain amount, he will be bound by such notice, and estopped from showing that he did not need or use that amount.

Brown *v.* Evans, 18 Nev., 141.

Flumes do not change general character of a ditch.

See Ditch, character of, not changed by flumes.

Foreign water.

See Water-course, natural, may be utilized.

Government, right of, as riparian owner.

See Riparian rights, Government as owner.

Indian, appropriation by.

See Appropriation, Indian may acquire right by.

Injunction, decree construed.

A decree which forbids interference with the waters of a creek which rise above a certain dam does not prohibit the use and enjoyment of the waters which may remain and flow down after the ditch of the complaining party has been supplied, but simply prevents interference with the water above the dam or the amount necessary to fill such ditch.

American Co. *v.* Bradford, 27 Cal., 360.

Injunction, jurisdiction of superior courts.

The superior courts in California have jurisdiction to grant a preliminary injunction restraining an alleged trespasser from diverting the waters of a stream during litigation and to require him to remove the means by which the diversion is made.

Johnson *v.* Superior Court, 65 Cal., 567.

Injunction granted to prevent acts injurious to a water right.

An appropriator of water is entitled to protection against acts which materially diminish the quantity of water to which he is entitled or deteriorate its quality for use to which he desires to apply it. Equity affords the appropriate remedy, by way of an injunction, for such wrongs.

Cole Silver Mg. Co. *v.* Virginia Gold Hill W. Co., 1 Saw., 470; Tuolumne Water Co. *v.* Chapman, 8 Cal., 392; Rupley *v.* Welch, 23 Cal., 452; Phœnix Water Co. *v.* Fletcher, 23 Cal., 481; Moore *v.* Clear Lake Water Works, 68 Cal., 146; Lake *v.* Tolles, 8 Nev., 285; Barnes *v.* Sabron, 10 Nev., 217; Harris *v.* Shontz, 1 Mont., 212; Gallagher *v.* Basey, 1 Mont., 457; Barkley *v.* Tieleke, 2 Mont., 59; Fabian *v.* Collins, 3 Mont., 215; Schilling *v.* Rominger, 4 Colo., 100; Keeney *v.* Carillo, 2 N. M., 480; Crane *v.* Winsor, 2 Utah, 248.

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Injunction the proper remedy for injury to a riparian right.

Equity, by way of injunction, affords to a riparian proprietor the proper remedy against the wrongful diversion or obstruction of the waters of a natural water-course.

Lux *v.* Haggin, 69 Cal., 255; Shively *v.* Hume, 10 Ore., 76; Weiss *v.* Oregon Iron and Steel Co., 10 Ore., 496.

Injunction, when issued to protect water rights.

Where it is shown that the injury to a water right is continuing or likely to be continued, a judgment for damages may be sustained, but an injunction should not issue.

Coker *v.* Simpson, 7 Cal., 340.

Injunction, when, will be granted to prevent injury to a water right.

Whether a court of equity will interfere to restrain acts claimed to be injurious to the rights of a prior appropriator of water will depend upon the character and extent of the injury alleged, whether it be irremediable in its nature, whether an action at law would afford an adequate remedy, whether the parties are able to respond for the damages resulting from the injury, and other considerations which ordinarily govern a court of equity in the exercise of its preventive process of injunction.

Atchison *v.* Peterson, 20 Wall., 507.

Injury not always necessary to justify an action.

There may be an invasion of a right which will justify an action although actual damage is not shown. But a distinction must be taken between those uses of water which are the exercise of the riparian proprietor's natural rights and those which are not; in the former case actual damage must be shown, but need not be in the latter.

Union M. & M. Company *v.* Dangberg, 2 Saw., 450.

Injury to joint property.

If one of two joint owners of a flume used for mining purposes consents to or directs the cutting of a water ditch above the flume, whereby the water from the ditch flows over and injures the flume, the parties thus opening the ditch, in compliance with the request of one of the joint owners of the injured property, can not be held liable for the injuries that followed.

Crary *v.* Campbell, 24 Cal., 634.

Injury to water used for mining.

Where a large number of persons are mining on a small stream and each deteriorates the water a little, so that the combined acts of all render the water unfit for use, each of such persons can not successfully defend an action on the ground that his act alone did not materially affect the water.

Hill *v.* Smith, 32 Cal., 166.

Injury, who liable for.

Where two or more parties act, each for himself, in producing a result injurious to another, they can not be held jointly liable for the acts of each other.

Blaisdell *v.* Stephens, 14 Nev., 17.

Invasion of water right, remedy for.

See Injunction granted to prevent acts injurious to a water right.

Irrigation.

See Eminent domain, riparian rights, use for street sprinkling.

Joint liability.

See Injury, who liable for.

Joint property, liability for injury to.

See Injury to joint property.

Jurisdiction of suit for injury to water right.

See Ditch, water right co-extensive with.

Land, condemnation of, for ditch purposes.

See Eminent domain.

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Land, covenant which runs with.

See Covenant which runs with land.

Land, possession sufficient for maintenance of action for injury thereto.

See Possession.

Liability of corporation to stockholders.

See Damages, liability of corporation to stockholders.

Limitations, statute of.

The statute of limitations does not commence to run with regard to lands held under a Mexican or Spanish grant until the final confirmation thereof by the Government of the United States.

Richardson *v.* Williamson, 24 Cal., 289; Reed *v.* Spicer, 27 Cal., 57; Anderson *v.* Fisk, 36 Cal., 625.

Limitations, statute of, effect on action for diversion of water.

Actions for diversion of water must be brought within the period prescribed by the statute of limitations after the date the cause of action accrued. The continuance of the wrongful diversion is a new cause of action or a new nuisance.

Toombs *v.* Hornbuckle, 3 Mont., 193.

An adverse, exclusive, and uninterrupted use and enjoyment by one person and those under whom he claims of all the water of a creek taken therefrom by means of a ditch and conveyed to certain mining grounds for mining purposes for twelve years, or for any period beyond that of the statute of limitations prescribing the time of entry shall be made upon real property, will bar the owner of the land through which the creek runs of his riparian rights; but where the ditch was constructed in which he reserved the right to use the water a part of each year for his own purposes such adverse use by grantees from the original appropriator can not be established unless it is shown that the use of the water by them has been in hostility to the use of it by the owner under such reservation.

Huston *v.* Bybee, Ore., Lawyer's Reports, 1889, II, 568.

Maintenance of ditch, extent of liability for.

See Estoppel, Use of water, Notice.

Miners and agriculturists, relative rights.

Where the titles of two parties to public mineral land rest on possession alone—one using it for mining and the other for agricultural purposes—the older possession, as between the two, gives the better right. In the use of their lands they are to be governed by the common-law rule applicable to adjoining land-owners, expressed in the maxim, *Sic utere tuo ut alienum non lædas.*

Wixon *v.* Bear River & Auburn W. & Mg. Co., 24 Cal., 367; Gibson *v.* Puchta, 33 Cal., 310.

Miners' rights.

Miners have no right to enter upon private land and subject it to such uses as may be necessary to extract the precious metals which it may contain. These operations are calculated to destroy the entire value of the land, and will be restrained by injunction.

Boggs *v.* Merced Mining Co., 14 Cal., 279; Henshaw *v.* Clark, 14 Cal., 461.

Miners' rights, injury to.

See Injury to water used for mining.

Miners' rights not superior to those of other appropriators.

The rights of miners and persons owning ditches constructed for mining purposes are not necessarily paramount to other rights and interests of a different character, but their superiority must rest upon priority in acquisition. One who appropriates for mining purposes the waters of a stream must take and use the same in such manner as not to injure the property rights of others acquired prior to the time the water was thus appropriated.

Wixon *v.* B. R. and A. W. & M. Co., 24 Cal., 367; Hill *v.* Smith, 27 Cal., 476; Levaroni *v.* Miller, 34 Cal., 231.

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Miners' rights to water of a stream.

The true rule governing the rights of several miners located on the same stream is that each is entitled to use in a proper and reasonable manner both the channel of the stream and the water flowing therein, and where, from the situation of the claims, the natural and necessary consequence of the working of some will result in injury to others it will be *damnum absque injuria*, and will furnish no cause of action to the party injured.

Esmond *v.* Chew, 15 Cal., 137.

See Appropriation, rights acquired by.

Miners' rights, rule governing.

Miners who have located claims on the side of a hill subsequently to the location of others in the bed of a stream in the vicinity must so use and work their claims as not to injure those of the prior locators.

Logan *v.* Driscoll, 19 Cal., 623.

Navigable stream defined.

Where a stream is naturally of sufficient size to float mill-logs, timber, and small boats, the public have a right to its free use for that purpose; nor is it essential that such capacity continue through the year.

Shaw *v.* Oswego Iron Co., 10 Ore., 371.

Negligence, liability for, in construction of dam or ditch.

One who constructs a dam or ditch for the purpose of appropriating water is bound to exercise in the construction and management thereof that degree of care and prudence which men generally, or ordinarily prudent men, use in like instances when the whole risk is their own. Both the degree and fact of prudence must depend upon the particular circumstances.

Hoffman *v.* Tuolumne County W. Co., 10 Cal., 412; Wolf *v.* St. Louis Independent Water Co., 10 Cal., 541; Fraler *v.* Sears Union Water Co., 12 Cal., 555; Burbank *v.* W. Walker River Ditch Co., 13 Nev., 431; Turner *v.* Tuolumne County W. Co., 25 Cal., 398; Richardson *v.* Kier, 34 Cal., 63; Campbell *v.* B. R. & A. W. & M. Co., 35 Cal., 679.

Notice of appropriation.

An appropriator of water who, after duly posting a notice of his intention to take the water and while prosecuting the work for perfecting such appropriation, posts a second notice of intention to take the same water, does not thereby abandon his claim under the first notice. Notices of intention to appropriate water are to be liberally construed.

Osgood *v.* El Dorado Co., 56 Cal., 571.

Notice of appropriation.

The notice of intention to appropriate, in order to cause such appropriation to relate to the date of the notice, must be sufficient to put a prudent man on inquiry.

Kimball *v.* Gearhart, 12 Cal., 27; Robinson *v.* Imperial Silver Mg. Co., 5 Nev., 44.

Notice of nuisance, when necessary.

A party who continues a nuisance, but is not the original creator of it, is entitled to notice that it is a nuisance, and a request must be made that it may be abated before an action will lie for that purpose, unless it appear that he had knowledge of its hurtful character; when the extent of the nuisance was increased by such party the rule is otherwise.

Grigsby *v.* Clear Lake W. Co., 40 Cal., 396.

Notice, what, necessary.

The inclosure of ground is not necessary to give notice of appropriation of public land for a canal or ditch.

Conger *v.* Weaver, 6 Cal., 548.

Nuisance, diversion of water.

See Action for diversion of water.

The diversion of a water-course or of water from one rightfully entitled to the use thereof is a private nuisance.

Parke *v.* Kilham, 8 Cal., 77; Tuolumne Water Co. *v.* Chapman, 8 Cal., 392.

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Nuisance, pollution of water.

The owners of a water ditch are entitled to have the water flow therein in its natural state when they claim such water by appropriation, and its pollution by a stranger is a private nuisance.

Crane *v.* Winsor, 2 Utah, 248.

Nuisance, parties defendant.

Where several parties owning mines at different points on the same stream or its tributaries discharge the débris from said mines into the stream, by which it is carried down and deposited on the lands of another, said miners may all be properly made parties defendant in a suit to enjoin such action.

The Mining Débris Case, 8 Saw., 628.

Nuisance, public, a private person may maintain an action against.

A private person may maintain an action against a public nuisance if it is specially injurious to himself or his property.

The Mining Débris Case, 9 Saw., 441; Blanc *v.* Klumpke, 29 Cal., 156; Grigsby *v.* Clear Lake Water Co., 40 Cal., 396.

Nuisance, when notice before action to abate necessary.

See Notice of nuisance, when necessary.

Nuisance, who may sue to enjoin.

One tenant in common of land injured by a public and private nuisance may sue to enjoin the nuisance without making his co-tenant a party to such suit either as complainant or defendant.

The Mining Débris Case, 8 Saw., 628.

Obstruction, right of appropriator to remove.

See Appropriator, right to remove obstruction.

Obstruction, right of riparian proprietor to place, in the stream.

See Riparian rights.

Overflow of land, prescriptive right.

See Easement for flow of water.

Owner of ditch, public carrier.

See Ditch-owners as carriers, duties of.

Parties, proper in action for diversion.

The several appropriators of the water of a stream have not that community of interest that would qualify them to maintain a joint action for the diversion of the water and for a settlement of the various rights of such appropriators.

Schultz *v.* Winter, 7 Nev., 130.

Parties, who necessary, in suits concerning water rights.

In an action to determine the relative rights of parties to the use of the water of a stream, those persons above who have diverted water from said stream and returned it undiminished in quantity before it reaches the party claiming to be injured are not necessary parties to such suit.

Smith *v.* Logan, 18 Nev., 149.

Partition of water.

Water flowing in a ditch is not susceptible of division, and where such property is held by tenants in common, the only partition the courts can make is to order a sale and a distribution of the proceeds.

McGillivray *v.* Evans, 27 Cal., 92; Lorenz *v.* Jacobs, 59 Cal., 262.

Partners, conveyance by one does not affect the interests of the other.

One of two parties who appropriate water by means of a ditch can convey only his interest therein; he can not by his conveyance affect the interest of the other in the water nor his right to the use of the ditch for the flow of the water to which he is entitled.

Henderson *v.* Nichols, 67 Cal., 152.

Percolating water.

Percolating water, or water passing through the soil in any manner other than in a well-defined channel, cannot be distinguished from the estate itself, and the owner of the soil may use it as he may desire, free from any usufructuary rights of others.

Hanson *v.* McCue, 42 Cal., 303; Huston *v.* Leach, 53 Cal., 262; Cross *v.* Kitts, 69 Cal., 217; Mosier *v.* Caldwell, 7 Nev., 363; Strait *v.* Brown, 16 Nev., 317.

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Percolating water.

When it does not appear that a spring is fed by any defined flowing stream, it must be presumed that it is formed by the ordinary percolations of water in the soil.

Hanson *v.* McCue, 42 Cal., 303.

Personal property, when water becomes.

Water, when collected in reservoirs or pipes, and thus separated from the original source of supply, is personal property, and is as much the subject of sale as ordinary goods and merchandise.

Heyneman *v.* Blake, 19 Cal., 579.

Place of use.

The right to water acquired by prior appropriation is not in any way dependent upon the *locus* of its application to the beneficial use designed or to the particular use to which it was first applied.

Atchison *v.* Peterson, 20 Wall., 507; Maeris *v.* Bicknell, 7 Cal., 261; McDonald *v.* B. R. & A. W. & Mg. Co., 13 Cal., 220; Davis *v.* Gale, 32 Cal., 26; Coffin *v.* Left Hand Ditch Co., 6 Colo., 443; Thomas *v.* Guiraud, 6 Colo., 530; Woolman *v.* Garringer, 1 Mont., 535.

Point of diversion.

One entitled to divert a quantity of water from a stream may take the same at any point on the stream, and may change the point of diversion if the rights of others be not injuriously affected by the change.

Kidd *v.* Laird, 15 Cal., 161; Butte Table Mg. Co. *v.* Morgan, 19 Cal., 609; Junkans *v.* Bergin, 67 Cal., 267; Sieber *v.* Frink, 7 Colo., 148; Hobart *v.* Wicks, 15 Nev., 418.

One entitled to divert a quantity of water from a stream can not change the point of diversion, if by such change the rights of other appropriators be injuriously affected.

Butte Table Mg. Co. *v.* Morgan, 19 Cal., 609; Nevada Water Co. *v.* Powell, 34. Cal., 109; Columbia Mg. Co. *v.* Holter, 1 Mont., 296.

One having acquired a right to divert water, whether by express grant or by prescription, whether such right rests in the parole license or the presumed consent of the proprietor, may change the point of diversion at pleasure, if the rights of others are not injuriously affected by such change. The difference as to the manner in which such a right was acquired relates to the mode of determining the existence and extent of the right, and not to the manner of its exercise and enjoyment.

Kidd *v.* Laird, 15 Cal., 161.

Pollution of water a nuisance.

See Nuisance, pollution of water.

Possession sufficient to maintain action for injury to land.

The rightful possession of land is sufficient to enable one to maintain an action for an interruption to that possession or for any injury to the property.

Crandall *v.* Woods, 8 Cal., 136; McDonald *v.* B. R. & A. W. & M. Co., 13 Cal., 220; Norris *v.* Glenn, 1 Idaho, 590; Simpson *v.* Williams, 18 Nev., 432.

Powers of water commissioners.

See Water commissioners.

Practice, distinct causes of action.

An entry upon and ouster from a dam-site and dam in process of construction and a canal-site, and canal in process of construction, and a diversion of the water claimed by means of the dam and canal, are two distinct causes of action, which can not be united in the same statement of cause of action in a complaint, but should be separately stated.

N. C. & S. Canal Co. *v.* Kidd, 37 Cal., 282.

Practice, local customs must be proven.

Courts will not take judicial notice of local customs. One who alleges the existence of a right to water appropriated under a local custom, such as is recognized by the act of July 26, 1866, must prove the existence of such custom.

Lewis *v.* McClure, 8 Ore., 273.

Prescription.

A right to the use of water may be acquired by an exclusive and uninterrupted enjoyment of the water in a particular way for a period corresponding to the time fixed by statute of limitations as a bar to an entry on land.

Crandall *v.* Woods, 8 Cal., 136; Union Water Co. *v.* Crary, 25 Cal., 504; American Co. *v.* Bradford, 27 Cal., 360; Los Angeles *v.* Baldwin, 53 Cal., 469.

Prescription—Continued.

One who was allowed, at a time when there was sufficient water in the stream to supply the wants and demands of all parties, to divert and use water without objection by a riparian owner or former appropriator, but whose use and diversion were objected to when the water became scarce and the supply insufficient for all, does not by such use acquire a prescriptive right to such water.

Feliz *v.* City of Los Angeles, 58 Cal., 73; Anaheim Water Co. *v.* Semi-Tropic Water Co., 64 Cal., 185.

No right by prescription can be acquired as against the Government.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176; Mathew *v.* Ferrea, 45 Cal., 51; Ogburn *v.* Conner, 46 Cal., 346; Wilkins *v.* McCue, 46 Cal., 656; Vansickle *v.* Haines, 7 Nev., 249.

If one goes upon public land of the United States and appropriates water for a lawful purpose, and is permitted to continue in its adverse enjoyment and use for more than ten years, such appropriation ripens into a title which can not be disturbed by one succeeding to the rights of the United States.

Tolman *v.* Casey, 15 Ore., 83.

One who has acquired a prescriptive right to the use of water as against a proprietor on a natural stream can not claim such right against the same person as to lands lying farther down the stream and afterwards acquired from the Government by him.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

Prescription, burden of proof.

The burden of proving an adverse use of water for the statutory period, with the knowledge and acquiescence of the person having the prior right, is cast upon the person alleging such adverse use.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176; the Mining Débris Case, 9 Saw., 441; American Co. *v.* Bradford, 27 Cal., 360.

Prescription, extent of right.

The right acquired by prescription is measured by the right enjoyed; it is always confined to the right as exercised for the full period of time prescribed by the statute.

Boynton *v.* Longley, 19 Nev., 69.

Prescription pleadings.

One claiming a right to water by virtue of the adverse use thereof for the statutory period must set up said right in his pleadings in order to entitle him to submit testimony in support of such claim.

American Co. *v.* Bradford, 27 Cal., 360; Lux *v.* Haggin, 69 Cal., 255.

Prescription, what necessary to establish right by.

One who claims a right to water by reason of an adverse use for the statutory period must show that such use was open, peaceable, and uninterrupted, and under claim or color of right.

Union M. & M. Co. *v.* Daugberg, 2 Saw., 450; the Mining Débris Case, 9 Saw., 441; Grigsby *v.* Clear Lake Water Co., 40 Cal., 396; Cave *v.* Crafts, 53 Cal., 135; Ledu *v.* Jim Yet Wa, 67 Cal., 346; Winter *v.* Winter, 8 Nev., 129.

To establish a right by prescription or adverse use, the acts by which such right is sought to be established must operate as an invasion of the rights of the party against whom it is set up. The enjoyment relied upon must be of such a character as to afford ground for an action by the other party.

Union M. and M. Co. *v.* Ferris, 2 Saw., 176; Grigsby *v.* Clear Lake Water Co., 40 Cal., 396; Anaheim Water Co. *v.* Semi-Tropic Water Co., 64 Cal., 185; Dick *v.* Bird, 14 Nev., 161; Dick *v.* Caldwell, 14 Nev., 167; Boynton *v.* Clear Lake Water Co., 40 Cal., 396.

Prescription right to overflow land.

See Easement for overflow of water.

Prior appropriation.

See Appropriation.

Private property may be taken for public use.

See Eminent domain.

Property of Government in stream.

The Government, as proprietor of lands through which a stream of water naturally flows, has the same property right in the stream that any other owner of land has, be it usufructuary otherwise.

Union M. and M. Co. *v.* Ferris, 2 Saw., 176; The Mining Débris Case, 9 Saw., 441; Lux *v.* Haggin, 69 Cal., 255; Vansickle *v.* Haines, 7 Nev., 249.

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Protection of land against stream, right of.

See Riparian proprietor.

Public land, easement on.

Land claimed by a pre-emptor remains public land until he proves up and pays for it. Land upon which pre-emption filing is placed after the passage of the acts of July 26, 1866, and July 9, 1870, may at any time before proof and payment be subjected to the right of way for a ditch or reservoir under the provisions of said acts.

Farley *v.* Spring Valley M. and I. Co., 58 Cal., 142.

See Statutes, act July 29, 1866.

Public lands, rights acquired by possession.

See Miners and agriculturists, Relative rights, Riparian rights.

Public land, rights of settlers on.

A tract of the public domain upon which one has settled with the intention of acquiring title thereto under the pre-emption law remains public land subject to disposition by the proper authorities until such settler has perfected his right by showing compliance with the requirements of said law and payment of the purchase price.

Frisbie *v.* Whitney, 9 Wall., 187; Yosemite Valley Case, 15 Wall., 77; Hutton *v.* Frisbie, 37 Cal., 475; Western Pac. R. R. Co. *v.* Tevis & Kerr, 41 Cal., 489.

Occupation and improvement of public land with a view to pre-emption confers an inchoate right that may be protected by the courts against the claims of other persons who have not an equal or superior right. Such a settler however, acquires no vested right until the purchase money has been paid and a receipt issued.

Frisbie *v.* Whitney, 9 Wall., 187.

Purchaser of land presumed to have notice of water rights.

One who buys land is presumed to buy with notice of the water rights in use on the premises.

Coffman *v.* Robbins, 8 Ore., 278.

Real property, water in a natural stream is.

Although an appropriator may be entitled to the flow of the water undiminished at the head of his ditch, yet the water in the stream is not his personal property but a part of the realty, and he can not maintain an action for the value of the water, as for personal property sold and delivered, against one who has wrongfully diverted the waters of said stream.

7 Parks C. & M. Co. *v.* Hoyt, 57 Cal., 44.

Real property, water ditches and rights are.

See Water ditches are real property.

Reasonable use of water.

See Riparian rights, reasonable use.

Relation.

See Appropriation, relation.

Reservoirs, natural depressions.

One may utilize as a reservoir for storing water a natural depression on the public land which includes the bed of a stream, but he must see to it that no legal right of prior appropriators or other persons is in any way interfered with by his acts.

Larimer County R. Co. *v.* People *ex rel.*, 8 Colo., 614.

Right of way, change of direction of ditch.

One who has acquired the right to go upon a tract of land and construct a ditch across the same may change the course of such ditch from the line originally surveyed, and if such diversion worked no actual injury to the owner of the land, he will not be liable for even nominal damages.

Conger *v.* Weaver, 6 Cal., 548.

Right of way, conveyance of.

A deed which conveys the right of way for an existing ditch is in effect a conveyance of the ditch itself.

Reed *v.* Spicer, 27 Cal., 57.

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Right of way through city.

A municipal corporation which accepts the dedication of streets across which a ditch has been previously located and right of way therefor acquired, takes the same subject to the prior rights of the owners of the ditch; and when the necessities of the public require that such ditch be bridged at the street crossings, it is the duty of the city, and not of the owner of the ditch, to construct such bridges.

Denver *v.* Mullen, 7 Colo., 345.

Right of way under act of July 26, 1866.

Under act of Congress of July 26, 1866, one has a right to construct a ditch across the public lands of the United States, subject only to the liability of paying for any damage to the possession of a settler on the land.

Hobart *v.* Ford, 6 Nev., 77; Shoemaker *v.* Hatch, 13 Nev., 261.

Riparian owner, boundary line of land.

Where a navigable stream has been meandered in making the public surveys the meander line is run for the purpose of marking the sinuosities of the stream rather than the boundaries of the tract of land bordering on such streams, the stream itself and not the meander line as actually run on the ground is the true boundary of tracts bordering on such streams.

Railroad Company *v.* Schurmier, 7 Wall., 272; Minto *v.* Delaney, 7 Wall., 337; Moore *v.* Willamette Transportation Co., 7 Ore., 355.

Riparian proprietors.

The section of the civil code of California which provides "the rights of riparian proprietors are not affected by the provisions of this title" declares, in effect, that those appropriating water under the previous sections shall not acquire the right to deprive of the flow of the stream those who shall have obtained from the State a title to, or right of possession in, riparian lands before proceedings leading to appropriation were taken.

Lux *v.* Haggin, 69 Cal., 255.

The common law doctrine of riparian rights is unsuited to the condition of the State of Nevada.

Reno Smelting M. & R. *v.* Stevenson, (Nev.) Lawers' Reps. (1889), IV, 60.

Riparian proprietors, lease, estoppel.

An upper riparian proprietor, who enters into an agreement with a lower proprietor, whereby the latter grants for a certain term the right to the use of the waters of the adjoining stream for domestic purposes and irrigation is not, upon the expiration of the agreement, thereby estopped from asserting his rights as a riparian proprietor to the use of the waters of such stream.

Swift *v.* Goodrich, 70 Cal., 103.

Riparian proprietors, rights as against appropriators of water.

An appropriation of water on public lands of the United States, made after the act of July 26, 1866, did not give the appropriator any right as against a riparian owner under a grant from the United States made prior to said act.

Lux *v.* Haggin, 69 Cal., 255; Vansickle *v.* Haines, 7 Nev., 249.

Riparian proprietor, right to protect his land from injury by stream.

A riparian proprietor has a right to protect his land from a threatened change in the channel of an adjoining stream and to erect works to prevent the old course of the stream from being altered.

Barnes *v.* Marshall, 68 Cal., 569.

See Waste.

Riparian rights, division of water by parol agreement.

Where the water of a stream which passes through the lands of different persons has been divided by them by parol agreement, and each party has constructed ditches, and has received, cared for, and enjoyed his portion of said waters for years, such parol agreement should be upheld in equity.

Coffman *v.* Robbins, 8 Ore., 278.

Riparian rights, extent of.

The owner of land through or along which a natural stream flows has a right to the reasonable use of the water of such stream during its passage, but has no right in the *corpus* of the water.

Union M. & M. Co. *v.* Dangberg, 2 Saw., 450; Eddy *v.* Simpson, 3 Cal., 249; Crandall *v.* Woods, 8 Cal., 136: Kidd *v.* Laird, 15 Cal., 161; Hale *v.* McLea, 53 Cal., 578; Pope *v.* Kinman, 54 Cal., 3; Lux *v.* Haggin, 69 Cal., 255; Weiss *v.* Oregon Iron & Steel Co., 13 Ore., 496.

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Riparian rights, extent of—Continued.

Every proprietor of land through which flows a stream of water has a right to the use of the water flowing in its natural channel without diminution or obstruction, except so far as upper riparian owners may use said water for domestic use, stock, and reasonable irrigation.

Taylor *v.* Welch, 6 Ore., 198; Hayden *v.* Long, 8 Ore., 244; Coffman *v.* Robbins, 8 Ore., 278; Shively *v.* Hume, 10 Ore., 76.

The owner of land on a water-course has a right to the free flow of the water to his land without obstruction, and an owner above in protecting his land from injury can not cut off the water of the stream by a dam.

Bliss *v.* Johnson, 76 Cal., 597.

When a natural stream of water flows through lands belonging to different persons, each usually has the right to enjoy it for the ordinary purposes of life; the right to drink it, to use it for culinary purposes, and to water animals. Any surplus after these purposes are supplied may be used for irrigation, and should be equitably divided between the several proprietors.

Shook *v.* Colohan, 12 Ore., 239.

Riparian rights, extent of, necessities.

A riparian proprietor is entitled to take from the stream as much water as is necessary for watering his cattle and for domestic uses, even though such necessities may consume all the waters of the stream.

Union M. & M. Co., 2 Saw., 450; Ferrea *v.* Knipe, 28 Cal., 340; Hale *v.* McLea, 53 Cal., 578; Lux *v.* Haggin, 69 Cal., 255.

Riparian rights, equitable title confers.

One who has entered and paid for his land under the pre-emption law and has received a certificate of purchase, or one who has entered land under the homestead act and has continued to reside thereon, has the equitable title to such land, and is entitled to riparian rights.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

Riparian rights, Government as owner.

The Government, as proprietor of the land through which a stream flows, has the same property and right in the stream that any other proprietor would have.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

Riparian rights, grantees of Government.

The grantee or patentee of the Government acquires common-law rights in the waters flowing through the land granted, except when such rights are reserved.

Lux *v* Haggin, 69 Cal., 255; Vansickle *v* Haines, 7 Nev., 249.

A stream of running water is part and parcel of the land through which it flows inseparably annexed to the soil, and the use of it as an incident of the soil passes to the patentee of the land.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

Riparian rights, irrigation.

A riparian proprietor may take water from the stream and may make reasonable use of it for purposes of irrigation.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176; Ellis *v.* Tone, 58 Cal., 289; Anaheim W. Co. *v.* Semi-Tropic W. Co., 64 Cal., 185; Lux *v.* Haggin, 69 Cal., 255; Swift *v.* Goodrich, 70 Cal., 103; Coffman *v.* Robbins, 8 Ore., 278.

A riparian proprietor is not entitled to divert and use all the water of a stream for the purpose of irrigation without regard to the wants and necessities of other riparian proprietors, although the amount so diverted and used was no more than necessary for the irrigation of his lands.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176; Hale *v.* McLea, 53 Cal., 578; Ellis *v.* Tone, 58 Cal., 289; Larned *v.* Tangeman, 65 Cal., 334; Gould *v.* Stafford, 77 Cal., 66.

Riparian rights, obstruction of stream.

While a riparian owner to whom the water first comes in its flow has a right to use it for domestic purposes and for watering cattle, he has not the right to so obstruct the stream as to prevent the water running substantially as in a state of nature it was accustomed to run.

Ferrea *v.* Knipe, 28 Cal., 341; Lobdell *v.* Simpson, 2 Nev., 274.

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Riparian rights, possession confers.

One who appropriates public land acquires a right to the use of water flowing through it, and this right is good as against every one, except the Government and those who may have acquired prior rights thereto.

Crandall *v.* Woods, 8 Cal., 136; Leigh Co. *v.* Independent Ditch Co., 8 Cal., 323; Huston *v.* Byhee (Ore.), Sawyers Rep., 1889, II, 568.

Riparian rights, possession of unsurveyed lands.

A mere possessor of unsurveyed public land has no riparian rights.

Covington *v.* Becker, 5 Nev., 281; Lake *v* Tolles, 8 Nev., 285.

Riparian rights, reasonable use.

A reasonable use of the waters of a stream by a riparian proprietor may be defined as any use that does not work actual, material, and substantial damage to the common right which each proprietor has, as limited and qualified by the precisely equal right of every other proprietor.

Union M. & M. Co. *v.* Dangberg, 2 Saw., 450; Lux *v.* Haggin, 69 Cal., 255.

Sale of water, effect on prior right to its use.

One who has built a mill on a stream thereby appropriates the water-power at that point, and does not by the conveyance of the water at a point above his mill lose his prior right over one who has claimed the water below the mill for mining purposes.

McDonald *v.* Askew, 29 Cal., 200.

Springs.

The owner of a head spring is not justified in exhausting it, for purposes of irrigation, to the injury of owners lower down on the main channel of the of the stream.

Heming *v.* Davis, 37 Tex., 183.

Statutes, act of July 26, 1866.

The doctrine of right by prior appropriation was recognized by the act of Congress of July 26, 1866.

Atchison *v.* Peterson, 20 Wall., 507; Basey *v.* Gallagher, 20 Wall., 670; Union M. & M. Co. *v.* Ferris, 2 Saw., 176; Cave *v.* Crafts, 53 Cal., 135; Osgood *v.* El Dorado W. & M. Co., 56 Cal., 571.

The act of July 26, 1866, confirmed rights already held under the local customs, laws, and decisions of the courts; it did not introduce any new system or any new or different policy on the part of the Government; it recognized, sanctioned, protected, and confirmed the system already established and provided for its continuance.

Jennison *v.* Kirk, 98 U. S., 453; Broder *v.* Natoma Water Co., 101 U. S., 274; Titcomb *v.* Kirk, 51 Cal., 288; Jones *v.* Adams, 19 Nev., 78.

The act of July 26, 1866, conferred upon parties desiring to divert water from a natural stream the right to construct across the public lands ditches for that purpose, subject only to the liability of paying for any damages to the possession of a settler on such lands.

Hobart *v.* Ford, 6 Nev., 77; Shoemaker *v.* Hatch, 13 Nev., 261.

It is not necessary, in order that a right may be entitled to protection under section 9 of the act of July 26, 1866, that there should be a union of the three conditions therein mentioned; that is, that said right should be recognized by the local customs, laws, and decisions of the courts.

Basey *v.* Gallagher, 20 Wall., 670; Barnes *v.* Sabron, 10 Nev., 217.

The act of July 26, 1866, does not affect the rights of one who had acquired a right to land and water flowing across it prior to the passage of said act.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176; Union M. & M. Co. *v.* Dangberg, 2 Saw., 450; Lux *v.* Haggin, 69 Cal., 255.

The act of Congress of July 26, 1866, was adopted simply to protect those who were at the time diverting water from its natural channels on the public lands and no diversion had been previously authorized.

Vansickle *v.* Haines, 7 Nev., 249.

One has a right under the act of Congress (July 26, 1866) to go upon Government land and divert the waters of a natural stream, and to the extent of his appropriation he acquires a vested right therein, and whoever afterwards purchases above or below him takes subject to such prior appropriation.

Kaler *v.* Campbell, 13 Ore., 596.

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Statutes—General Statutes Colorado, section 1718.

That portion of section 1718, General Statutes of Colorado, which limits the amount of compensation to be paid to the owner of a ditch by one who desires to enlarge or use the same, under the provisions of said law, to a reasonable proportion of the cost of construction of said ditch, is unconstitutional. The compensation for taking or damaging private property against the owner's consent must be ascertained by a jury or board of commissioners.

Tripp *v.* Overocker, 7 Colo., 72.

Statutes, act of March 3, 1869, Nevada.

The statute of March 3, 1869, merely provides for a right of entry on the land of another for the purpose of surveying for a ditch or flume and the manner in which such lands may be condemned, and does not confer any right of priority upon one complying with its provisions.

Barnes *v.* Sabron, 10 Nev., 217.

Texas.

The colinization law of Texas and the statutes of the State recognize the right to use water for irrigation purposes.

Tolle *v.* Correth, 31 Tex., 362.

Statute of limitation.

See Limitations, statute of.

Subterraneous streams.

See Underground streams.

Tenants in common, appropriators are.

See Appropriators, tenants in common.

Trespasser, appropriation by.

See Water right, when an appurtenance.

Underground streams.

The rules of law which govern the use of streams flowing upon the surface of the earth are equally applicable to underground currents of water flowing in defined channels.

Hanson *v.* McCue, 42 Cal., 303; Cross *v.* Kitts, 69 Cal., 217; Keeney *v.* Carillo, 2 N. M., 480; Strait *v.* Brown, 16 Nev., 317; Taylor *v.* Welch, 6 Ore., 198; Shively *v.* Hume, 10 Ore., 76.

Use, beneficial, is test of appropriation.

See Appropriation.

Use, by riparian proprietor.

See Riparian rights, extent of.

Use of water for street sprinkling is use for irrigation.

A contract by which it is agreed to furnish water to the inhabitants of a city "for domestic purposes" does not include water for irrigation. Water used for sprinkling streets is water used for the purposes of irrigation.

Los Angeles Water Co. *v.* Los Angeles City, 55 Cal., 176.

Use, place of.

See Place of use.

Usufructuary rights.

See Appropriator's rights in water of a natural stream are usufructuary, Riparian rights, extent of.

Waste.

A person having the right to the exclusive use of the water flowing through a ditch constructed across the land at any point, where he may desire to turn it for irrigating purposes during the spring and summer months, has the preference during the season when he requires the water for irrigation, but he has no right to waste it at any time, at other times the owner of the ditch has the full right to use it.

Huston *v.* Byhee (Ore.), Lawyer's Rep. (1889), II, 568.

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Water commissioners, extent of authority.

A board of water commissioners, under the act of California of May 15, 1854, has no authority to enter upon a private water-course and to disturb the owners thereof in its use and enjoyment.

Charnock *v.* Rose, 70 Cal., 1-9.

Water commissioners' actions may be reviewed by the courts.

It is the duty of the board of water commissioners, upon petition, to locate and lay out a proposed water ditch, and when it is constructed to apportion the water among those interested according to their respective interests; but the action of the board in making such apportionment is subject to review by the courts.

Daley *v.* Cox, 48 Cal., 127.

Water companies, rights and privileges of.

Corporations organized to furnish the inhabitants of a city with pure, fresh water, like companies organized to furnish gas to the inhabitants of a city, are engaged in a "species of trade and commerce," and are governed by the provisions of the State law relating to such corporations.

Heyneman *v.* Blake, 19 Cal., 579; Price *v.* Riverside L. & I. Co., 56 Cal., 431.

Water course defined.

To constitute a water-course there must be bed, banks, and water; the water must usually flow in a certain direction and by a regular channel; the water need not flow continually, but the stream must have a well-defined and substantial existence.

Barnes *v.* Sabron, 10 Nev., 217.

Water-course, natural, used to carry water acquired by appropriation.

One who avails himself of a natural water-course to conduct water he has appropriated to the place where he designs to use it does not abandon the water thus turned into the natural stream, and may divert the same quantity at the place he desires to use it.

Hoffman *v.* Stone, 7 Cal., 46; Butte Canal & Ditch Co. *v.* Vaughn, 11 Cal., 143; Davis *v.* Gale, 32 Cal., 26; Ellis *v.* Tone, 58 Cal., 289; Schulz *v.* Sweeny, 19 Nev., 359.

Water-course, natural, used to convey water.

One who has brought water from a distance and emptied it into a natural stream with the intention of taking it out again may not so reclaim it as to diminish the quantity to which a prior locator or appropriator was entitled.

Butte Canal & Ditch Co. *v.* Vaughn, 11 Cal., 143; Burnett *v.* Whitesides, 15 Cal., 35; Wilcox *v.* Hausch, 64 Cal., 461.

Water-course, natural, used to convey water, burden of proof.

Upon one who turns water into a natural water-course for the purpose of conveying it to the place where it is to be used and there diverting it from said stream is cast the burden of showing that he has not taken from the stream more water than he turned into it.

Butte C. & D. Co. *v.* Vaughn, 11 Cal., 143; Wilcox *v.* Hausch, 64 Cal., 461.

Water ditches are real property.

A water ditch and the water right appurtenant thereto are real property.

Hill *v.* Newman, 5 Cal., 445; Lower Kings D. Co. *v.* Lower Kings R. & F. C. Co., 60 Cal., 408; Dodge *v.* Marten, 7 Ore., 456.

Whether ditch property in the mineral regions of this State, although conceded to be real estate, is to be regarded by courts of equity with the same measure of favor that is bestowed by them upon land held and cherished for itself, and whether such courts will interfere by way of injunction to protect ditch property, admits of at least serious doubt.

Clark *v.* Willett, 35 Cal., 534.

Water ditch, when public property.

An irrigating ditch, constructed, repaired, and controlled by two or more persons does not cease to be private property because they have not accurately defined their respective rights therein, or because they have selected some one to distribute the water among those interested therein. Such ditch is not subject to the control of the board of water commissioners for the district in which it is situated.

Cate *v.* Sanford, 54 Cal., 24.

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Water, diversion of.

See Diversion of water.

Water, personal property.

See Personal property.

Water right, co-extensive with ditch.

See Appropriator's right co-extensive with his ditch.

Water right, deed of, does not convey mill-site.

A deed conveying the right to the use of the water of a river between certain points does not convey the land of a mill-site on the river.
Robinson *v.* Imperial S. Mg. Co., 5 Nev., 44.

Water right, transfer of.

An executed contract which passed the equitable title to a ditch to which a water right was appurtenant, is sufficient to insure the grantee the rights for which he stipulated as against an adverse claimant.
Ortman *v.* Dixon, 13 Cal., 33.

The right to water acquired by appropriation is a species of realty, and requires for its transfer the same form and solemnity as is required for the conveyance of any other real estate.
Barkley *v.* Tieleke, 2 Mont., 59; Smith *v.* O'Hara, 43 Cal., 371.

Right to water acquired by appropriation may be transferred like other property.
McDonald *v.* B. R. & A. W. & M. Co., 13 Cal., 220; Union Water Co. *v.* Crary 25 Cal., 504; Dalton *v.* Bowker, 8 Nev., 190.

The right to the use of a water-course in the public mineral lands, and the right to divert and use the water taken therefrom acquired by appropriation, may be held, granted, abandoned, or lost by the same means as a right of the same character issuing out of lands to which a private title exists.
Union Water Co. *v.* Crary, 25 Cal., 504.

Water right, when an appurtenance.

A right which secures to the owner of a tract of land water for irrigating or other purposes necessary to the beneficial enjoyment of the land becomes appurtenant to said land and passes by a conveyance thereof.
Cave *v.* Crafts, 53 Cal., 135; Farmer *v.* Ukiah Water Co., 56 Cal., 11; Standart *v.* Round Valley Water Co., 77 Cal., 399.

If the right to use the water were acquired by appropriation for the purpose of operating a mill on the stream, such right would pass by the transfer of said mill property to a vendee.
McDonald *v.* B. R. & A. W. & M. Co., 13 Cal., 220.

The water supply of a mill will ordinarily pass with a conveyance of the mill, but in order to do so it must belong to the mill, must be the property of the owner thereof.
Ginocchio *v.* Amador C. & M. Co., 67 Cal., 493.

The purchase by a mining company of a water ditch and rights appertaining thereto does not necessarily constitute said ditch and water rights appurtenances of the mining claim. Upon one who asserts that a ditch and water rights are appurtenant to a mining claim is cast the burden of proving that such is the fact.
Quirk *v.* Falk, 47 Cal., 453.

The right to water appropriated to irrigate a certain tract of land by one who had no title to said land, but was a mere trespasser, does not become appurtenant to the land, and does not pass to a purchaser from the owner of the land.
Smith *v.* Logan, 18 Nev., 149.

To entitle one to recover in an action in ejectment he must show that he is entitled to possession of the premises; but he is not required to show that he is entitled to the enjoyment of a stream of water running through the premises or that he was damaged by the diversion of it.
Dilley *v.* Sherman, 2 Nev., 67.

When a canal or aqueduct has been constructed in two separate parts by different contractors at different times, the two sections being fed in part from different sources, and the Supreme Court of the United States has decided that the two sections constitute separate and distinct works, the water supply of the one must be held not an appurtenance of the other section.
Reynolds *v.* Hosmer, 51 Cal., 205.

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Water rights acquired under license to use.

One who takes possession of water under a verbal license to use the same, during the time that the grantor did not need the use thereof, acquires no rights which could be sold and transferred to another.

Fabian *v.* Collins, 3 Mont., 215.

Water rights are real property.

The right to running water may exist without private ownership of the soil upon the ground of prior appropriation. The right to water must be treated as a right running with the land and as a corporeal privilege bestowed upon the occupier or appropriator of the soil, and as such it has none of the characteristics of mere personality.

Hill *v.* Newman, 5 Cal., 445.

Water, use of, by those entitled may be regulated by a court of equity.

It is within the power and authority of a court of equity to ascertain and determine the extent of the rights of property in water, flowing in a natural water-course, acquired by persons who hold and are entitled to them, and to regulate between or among them the use in the flow of the water in such a way as to maintain equality of rights in the enjoyment of the common property.

Frey *v.* Lowden, 70 Cal., 550.

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